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EDITORIAL.

ITEMS AND NOVELTIES.

The Stevens Institute of Technology.—In our last number we made a brief general notice of this institution, and promised further details on subsequent occasions, and, in fulfillment of this promise, now proceed to the more minute description of some points likely to interest the mass of our readers.

The Building, of which a front view appeared in our last, is constructed of a hard blue trap rock, with trimmings of brown and grey sandstone. The length of the front or main building is 180 feet, and its depth 44 feet. The west wing is 60 by 30 feet, and the middle wing is 80 by 50. An east wing would render the plan symmetrical, but this has not been erected, as sufficient space for the present needs of the school is supplied without it. With the exception of the middle wing, all these portions have three floors, and a basement, and the aggregate floor space is thus a very little less than one acre, all of which is occupied with lecture rooms, laboratories and workshops.

The entire east wing is devoted to the use of the chemical department, containing an assay room, store-room, analytical laboratory for students, balance room, lecture room, mineral cabinet, also used for blowpipe analysis; special analytical laboratory, for advanced students, and study of the Chemical Professor.

The basement is occupied at its western end by the steam boilers used for heating and running the steam machinery, and by a series of furnaces for metallurgical work, including a small reverberatory furnace, built from drawings supplied by Prof. J. M. Ordway, of the Massachusetts Institute of Technology, through the kindness of President J. D. Runkle, of the same institution. Here are also to be found a forge, crucible furnace and other related appliances.

The eastern end of the basement, as will be seen from the accompanying plan, is occupied as a workshop. Here will be found at E′ a double cylinder engine of 25 H. P. At either side of L (one only being indicated in the plan), two lathes, one of 16 and the other of 10-inch swing, both with back gear and the usual attachments. At P, a planer of 3-foot table, and a small planer of 18 inches table, for light hand work. At M, one of Brown & Sharp's Universal Milling Machines and gear cutters, and in the same vicinity an upright drill and a small punch.

At W′ W′ and F′ are placed machinists' pattern-makers' and carpenters' benches, provided with the requisite attachments and tools.

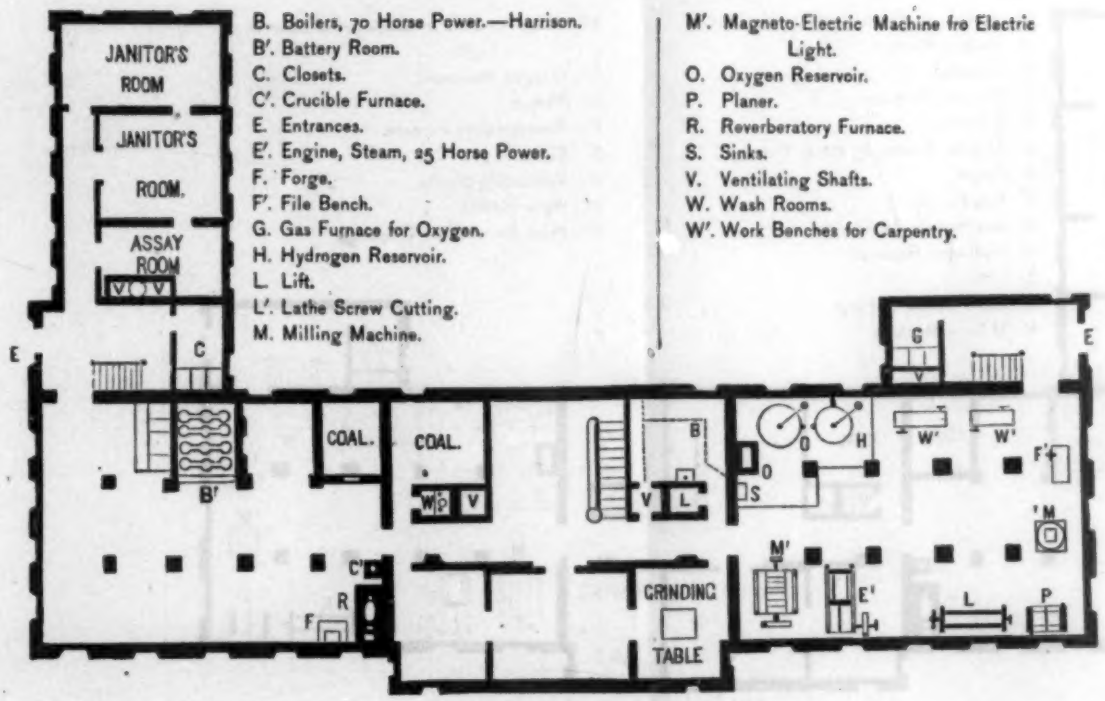
Within the same room, but shut off by a lattice iron partition, are the reservoirs for oxygen and hydrogen gases, under pressure, holding 100 cubic feet each, and connected by pipes with all the lecture rooms throughout the building.

In connection with the outfit of this machine shop, an Emerson Dynamometer has been provided, by which the actual power consumed by different machines, and in different kinds of work, can be accurately measured. A complete assortment of gauges, squares, callipers, scales, &c., by Darling, Brown & Sharp, have also been provided, so that the students in this department will have every facility for becoming familiar with the exactitude attainable and demanded in modern work.

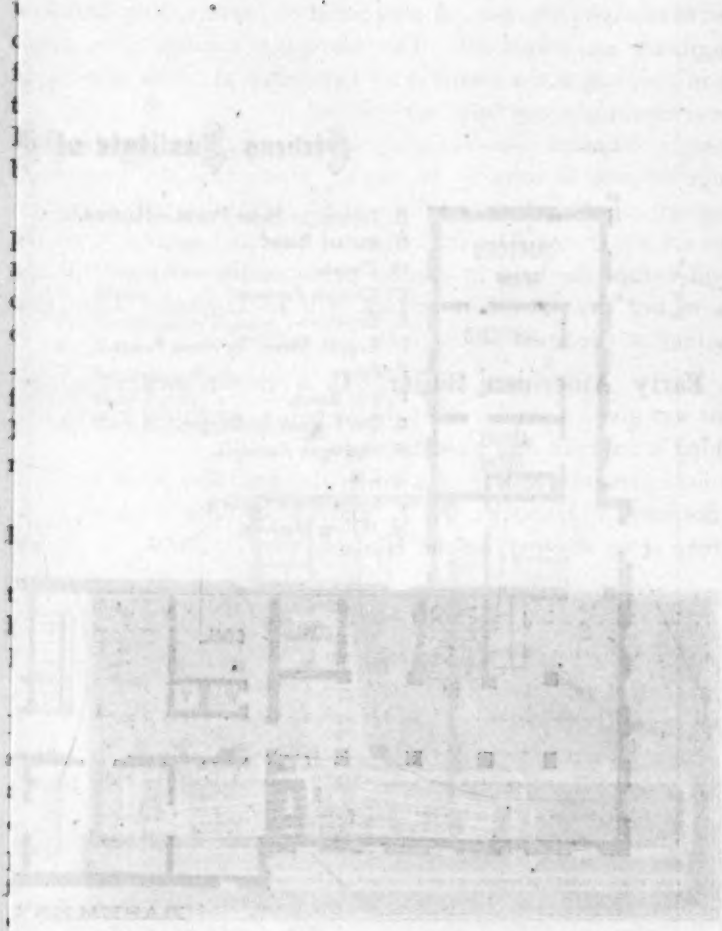
In our next number we will give some account of the arrangement of the Physical Laboratory, Library, Model Room, and Lecture Rooms for Mechanics, Physics and Engineering, and of the very extensive collection of apparatus, models and specimens which these contain.

Stevens Institute of Technology.

B. Boilers, 70 Horse Power.—Harrison.
B'. Battery Room.
C. Closets.
C'. Crucible Furnace.
E. Entrances.
E'. Engine, Steam, 25 Horse Power.
F. Forge.
F'. File Bench.
G. Gas Furnace for Oxygen.
H. Hydrogen Reservoir.
L. Lift.
L'. Lathe Screw Cutting.
M. Milling Machine.
M'. Magneto-Electric Machine fro Electric Light.
O. Oxygen Reservoir.
P. Planer.
R. Reverberatory Furnace.
S. Sinks.
V. Ventilating Shafts.
W. Wash Rooms.
W'. Work Benches for Carpentry.



BASEMENT.

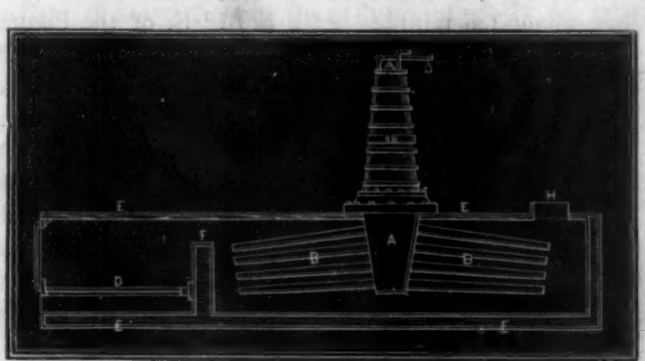


The East River Bridge.—Active operations in preparing for the erection of the East River Bridge have been begun at James' Slip, on the New York shore. The South Seventh Street Ferry has been removed to the next pier above, a new slip and ferry-house built, and wharf repairs made. The old ferry-house occupies about the centre of the space to be used by the bridge, and is now devoted to storage purposes. A number of carpenters, dock-builders and engineers are employed. The elevating engines have been placed in position, and a steam mud excavator at work removing the sewer accumulations from the bottom.

A very substantial platform is being made over the space where the huge caisson is soon to be sunk. Upon this the pumping, hoisting and other machinery will be fixed. Quantities of enormous timbers are used. At least thirty feet of the mud bottom must be taken off before the caisson can be permanently located. In less than a month this introductory task will be finished. Then the foundations of the great pier will be commenced.

An Early American Boiler.—In a recent number of the *Journal* was given a sketch of a tubular boiler, described originally something more than half a century ago.

We here present a sketch of a boiler designed and built by Col. John Stevens, of Hoboken, N. J., and successfully worked, in a small *twin screw* steamer, on the Hudson river, in 1804. A is the



boiler, *b b* the tubes closed at their outer ends, *c* the steam-drum, strengthened with iron bands, *d* the grate, and *e e e e* the outer double casing, filled with non-conducting material; *f* is the bridge-wall, and *h* the opening of the smokepipe.

The original of this remarkable example of early American en-

gineering is preserved, with the boat and machinery, at the Stevens Institute of Technology, at Hoboken, N. J.

That institution has also just received, through the kindness of Commodore Ammen, of the Navy Department, a model of a more recent example of naval engineering—a model of a proposed armored torpedo boat. R. H. T.

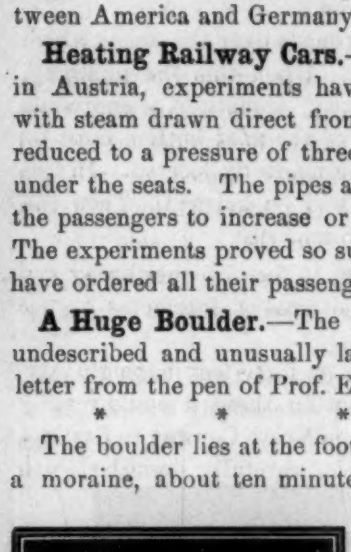
A New Cable is to be laid this summer by a German company, between England and Germany. By arrangements made with the English Atlantic Cable Companies, it will secure all the traffic between America and Germany.

Heating Railway Cars.—On the Kaiser Ferdinand Railroad in Austria, experiments have been made to heat passenger cars with steam drawn direct from the driving engine. The steam is reduced to a pressure of three atmospheres, and conducted by pipes under the seats. The pipes are furnished with cocks, which enable the passengers to increase or reduce the temperature at pleasure. The experiments proved so successful that the directors are said to have ordered all their passenger cars to be similarly heated.

A Huge Boulder.—The accompanying account of a hitherto undescribed and unusually large boulder has been received in a letter from the pen of Prof. Edwin J. Houston. We print it in full.

* * * * * *

The boulder lies at the foot of Bartlett Mountain, near the end of a moraine, about ten minutes' walk E. 31° S. of the Pequawket House of Mr. E. S. Stokes, North Conway, from which I propose to call it the Pequawket Boulder.



The general form of the boulder is that of an irregular parallelopipedon, one of whose longer sides is partially buried. From some cause or other, probably from one of the sides not being properly supported, the mass has fallen into two unequal parts, separated from each other by a space of a few inches. The general outline and dimensions of the upper face may be best seen from the annexed sketch.

The length along the line A B is 52 feet 6 inches. Its breadth

along G C is 21 feet; along F D 16 feet 7 inches, and along O M 10 feet. The length from B to the crack is 37 feet. Where the boulder has fallen apart, the breadth is 12 feet 1 inch. As the sides are almost vertical, the dimensions of the upper and lower faces are approximately the same. The position is indicated by the cardinal points, N., S., E. and W. The boulder is highest on the N. W. and S. W., the other sides, as before mentioned, being partially buried. The height at the point B is 33 feet 2 inches; at P, 28 feet 2 inches, at R, 19 feet 6 inches; at R′, 17 feet 2 inches; at M, 15 feet 3 inches; at A, 9 feet 3 inches; at O, 12 feet 2 inches; at T, 8 feet 5 inches; at F, 10 feet 2 inches; and at Q, 18 feet 3 inches.

The entire mass is composed of a coarse granite, containing a preponderance of feldspar, in rather large pieces, a fair proportion of quartz, and but little mica. Surrounding the boulder are several large fragments, which at one time evidently formed a part of its mass. In front, off the end Q P, there is a mass 31 feet 3 inches long, 15 feet broad, and 21 feet high. On the S. E. side there is another fragment, 31 feet 7 inches long, 15 feet 3 inches broad, and 11 feet 7 inches high. There are also smaller fragments on the other sides.

Several spruces and beeches, thirty or forty feet in height, surround the boulder. Indeed, were it not for these, it could readily be seen from the stage road leading from North Conway to Bartlett, and would, I feel confident, have been carefully described long before this.

A well marked moraine runs up the mountain from the boulder, N. 80° E. I climbed the mountain at this point, following the direction of the moraine by the compass. The moraine is distinctly marked nearly to the summit of the ridge, though the boulders are larger nearer the bottom. About 600 or 800 feet above the Pequawket Boulder they are of considerable dimensions. Several are in the neighborhood of $12 \times 13 \times 15$ feet. A few hundred feet below the Pequawket boulder, in the direction of the moraine, there is another large mass, measuring 31 feet in length, 18 feet in height, and 12 feet in breadth. All these boulders are of the same material. Assuming the boulder to be of the same thickness throughout, a rough estimate would make its weight about 2300 tons.

The rocks of the ridge at this part of the mountain are composed of a breccia, formed of fragments of an argillaceous shale, interspersed through a granite. This, of course, shows the granite to be

of a later formation than the shale. Although no portion of the shale was detected in the granite of the boulder, I think, from the close similarity in the mineral constituents of the two granites, that they were coeval in formation.

I write you hoping to bring this enormous boulder to the notice of a more practical geologist than myself.

Binocular Vision.—It is with pleasure that we are permitted to announce to our readers, that a series of papers on the phenomena of binocular vision will shortly appear in the pages of this *Journal* from the pen of Prof. Chas. F. Himes. The papers will be a thorough discussion of the subject, and will include a review of, and criticisms upon the several theories extant, as well as the results of original research.

Iron Paper.—The *Mining Journal* gives us the following account of what it declares to be the thinnest sheet of iron ever rolled. The mill-manager of the Upper Forrest Tin Works, near Swansea, has succeeded in producing, from iron made upon the premises, a sheet $10 + 5\frac{1}{2}$ inches, or 55 inches in surface, which weighs but 20 grains. When brought to the standard of 44 superficial inches, which previous competition had fixed as a standard of comparison, its weight is but 16 grains, or 30 per cent. less than any sample previously produced. Its thickness is estimated at $\frac{1}{1800}$ths of an inch.

Fuel for domestic purposes, it appears from one of our French exchanges, became so rare an article during the siege of Paris, that several ingenious devices were invented to meet the positive hardship suffered from its scarcity. One process that met with great favor was to saturate porous cylinders of clay prepared for the purpose, with bituminous substances. These were used like the charcoal, which is largely used under ordinary circumstances

A recent Balloon Ascension.—The following account of an ascension, attended with an experience of an unusually interesting nature, has been kindly furnished by Mr. John Wise, member of the Institute, by whom it was conducted.

On the 29th of July last, about noon, the atmosphere over and around Chambersburg, Pa., was more than ordinarily filled with storm clouds. Between the hours of one and three, two thundergusts passed near the town. I delayed the ascent of the balloon, in the hope that a thundergust would pass over us, or at least come near enough to enable the balloon to pass into its central uprising

vortex. Experience has taught me that a balloon, rising from the ground within the sphere of influence of the concentrating air moving from every part of the compass to the storm's vortical centre, will be drawn into that centre, which constitutes its uprising column.

At 3 P. M. a thundergust was approaching us from the northwest, and, with a view of entering it, the balloon was cast loose at 3 o'clock 20 min. The ascent was moderately rapid, and upon gaining an elevation of a thousand feet it was discernible that the storm cloud was passing us too far to the east, leaving the balloon outside of its *drawing-in* influence. It was a mushroon-shaped nimbus, bulged out above and below, trailing its lower ragged edge somewhat behind, and it seemed to labor between contending forces, as it swayed and halted in its onward march. The only great difference manifested now between former experiences and the present one, was the very low temperature of the air we were in. Looking upwards, I saw at a considerably greater elevation an isolated greyish-colored cloud, of an oblong shape, occupying a space of about a thousand acres (I say a thousand acres, because its shadow covered a dozen or more of farms below, and this outline gave me an approximate idea of its dimensions), and it seemed to be quiescent. My attention was now wholly directed to this, to me, new kind of meteor. The cold increased as we mounted up, and much faster than is usual in rising with a balloon. When yet at least a thousand feet below its apparent concave surface and ragged circumference, we entered a fine drizzling shower of snow, which became more copious as we rose towards the cloud, until we reached the point of the most visible deposition, which was equal to a regular snow fall, and as we rose from this point it seemed to diminish in quantity, until we reached the lower surface of the cloud, where it ceased, but we could still see the snow falling below us. While it was at a freezing temperature below, as soon as we had fairly become involved in the cloud, the air began to grow warmer. In the cloud it was not near so dark or dingy as in a thunder cloud, but the light was of a greenish tint. When we emerged from the top of the cloud, the heat, or rather the increase of heat, was sudden, and the sun, shining on our necks and hands, produced an effect I can only compare to the contact of an acid spray, producing a burning sensation.

The cloud just mentioned showed no *bubbling up* upon its sur-

face, as is the case over a thunder cloud, and whatever may have been the action taking place within it, it was of a most placid character. On suffering the balloon to drop down through it, we again encountered the snow—less in quantity, but the cold sudden and intense, and immediately both of us became hoarse, with a painful, irritating sensation in the windpipe, indicating a corrosive action there. May this be the action of ozone upon moist animal membranes? I have great reason to believe that such is the explanation of the fact, as it seemed to me that the mere change of temperature could not produce that marked effect. I may mention, in this connection, that I have frequently experienced the same sensation upon entering a storm cloud.

With these statements my communication will close. I have confined myself strictly to a rehearsal of facts, in order that meteorologists to whom these presents may come, shall be unencumbered in making use of them, should they prove in any sense useful.

The Westfield Explosion.—Previous to holding an inquest, Coroner Keenan addressed a letter to Prof. R. H. Thurston, of the Stevens Institute, Hoboken, desiring him to make a thorough investigation into the cause of the explosion of the boiler of the Westfield, as he wished the opinion of a scientific man to be presented to the Coroner's Jury. Professor Thurston signified his willingness to make the examination, and has been furnished with the necessary authority by the Coroner. During the progress of the inquest, the Coroner retains the Professor as an expert, to assist him in the examination of expert witnesses.

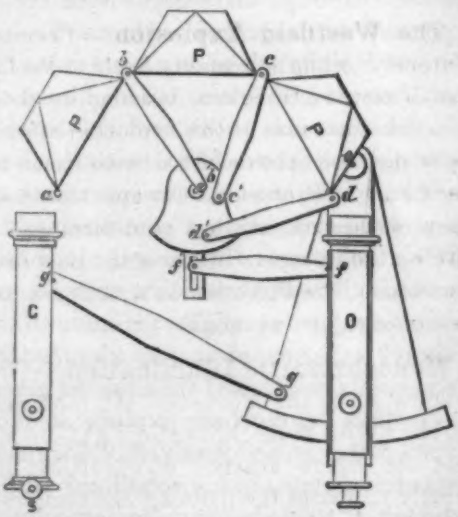
Monochromatic Illumination.—Count Castracane, in a communication to the *Microscopic Journal*, gives some results of his experience with monochromatic light in microscopsy. He declares that the entire absence of chromatic aberration thus obtained greatly increases the defining and penetrating power of the instrument, and strongly recommends to microscopists a more general introduction of the plan. The only essentials are sunlight and a prism; in default of the former, any of the well known means for obtaining a brilliant white light may be resorted to. For the purposes of observation, blue and green are the colors recommended.

A New Light.—In the *Journal l'Eclairage aû Gaz* is given a plan for a new system of illumination. The author, Dr. Harcourt, proposes to mix burning gas with a certain proportion of air, and

to allow the mixture to impinge upon platinum-sponge. The result, it is claimed, is the production of a more brilliant light without increased expense.

Sulphur in Coal Gas.—A simple process of detecting the presence of sulphur in burning gas, is given by Ulex.* It is only necessary to take a clean platinum dish, and evaporate in it about a pint of water, with the gas flame of the Bunsen burner. The outside of the vessel, when examined, will be found to be partly coated with an oily fluid, which can be distinctly shown, by the ordinary qualitative tests, to be sulphuric acid. The white incrustation which makes its appearance on the inside of lamp chimneys, is declared by the same author to consist of sulphate of ammonia, which may also be qualitatively recognized.

An Automatic Spectroscope.—The accompanying engraving represents the plan of a spectroscope designed by Mr. Grubb, to adjust itself automatically to the minimum angle of deviation for the ray under examination.† The design will be found upon inspection to present considerable differences, though essentially the same in principle, to that described in this *Journal*, (LXI. 153) in the notice of the spectroscopes of Messrs. Rutherfurd and Browning. In this, however, the prisms are attached to a central disk, by means of levers at their points of juncture, and not by their bases. The collimator is stationary, pointing at the centre of the face of the first prism. The arm to which the observing telescope is attached, is united with the central disk in such a way that any motion communicated to it will cause the disk, and therefore the prisms, to fall into the proper position for the examination of any ray.



* Zeitschrift für Anal. Chem. X. 246.

† Quart. Jour. Science, xxx. 270.

Condensation of vapor by changes in tension and temperature.—A very simple and yet effective method of demonstrating the above action has been observed by Mr. Wm. E. Geyer, instructor in Physics and Mathematics in the Stevens High School. If a pipette with a glass bulb about an inch in diameter, is provided with an elastic rubber elipsoid, as when used for tank experiments in the lantern, and is moistened with water inside by being filled and emptied; then if the air is partially expelled by compressing the rubber ball, the point of the pipette closed with the finger, and the rubber released, a cloud at once fills the glass bulb. This is immediately dispersed by renewal of pressure only to reappear on its relief. The pipette should be held between the eye and the light.

Properties of Nitro-Glycerine.—From the researches of P. Champion, published in the *Comptes Rendus*, we are furnished with a very thorough knowledge of the physical properties of this important but dangerous product. The results of Kopp's labors previously published amongst our *Items* list are confirmed and much addditional intelligence is added by the late research. The following abstract may prove useful:—Nitro-glycerine is soluble in ether and alcohol, (above 50° C. with the latter) and totally insoluble in water. It is not liable to spontaneous decomposition when *pure;* and when exposed to a continued cold of —2° C., it is converted into a solid crystalline mass. It is decomposed by fuming nitric and also by sulphuric acids, or by a mixture of the two, thus accounting for the slight variation from the theoretical quantity always experienced in the manufacture of the material (by the action of a mixture of the acids on glycerine).

It boils but does not explode at 185° C., volatilizes rapidly at 200°, deflagrates violently at 257°. At a red heat it assumes the spheroidal state, and is volatilized without explosion; and finally though it explodes with violence by a blow—the electric spark does not affect it.

The American Association for the Advancement of Science.—The twentieth annual meeting of the American Association was inaugurated on Wednesday, August 15th, at Indianapolis, Indiana. The Association receives, on the morning of this day, an address of welcome from the Governor of the State. The meeting is quite largely attended and promises to be one of unusual interest. The retiring President, Dr. T. Sterry Hunt, delivers on the occasion of his retirement an address upon the Origin of the

Crystalline Rocks. The citizens of the town and state are fully alive to the importance of the meeting, in connection with the proper appreciation on the part of their scientific visitors, of their material interests, and have very sensibly made arrangements for their proper reception and comfort. Excursions have been arranged for various places of interest in and out of the state, including, among other things, a visit to the centres of the coal and iron industries, and one to Terre Haute, the citizens of which city have contributed $1000 for the proper reception and entertainment of their guests.

A Substitute for Wood Engraving.—The new mechanical agent, the "jet of sand," has as yet, we are fully convinced, only exhibited a fraction of its possible applications. The latest adaptation its ingenious inventor has succeeded in developing into practical efficiency, is to a peculiar process of replacing the art of wood cutting. The few experiments conducted in this direction have given such promise of success, that we feel justified in predicting for it a most important role in the future of the art it represents. We hope, in our next issue, to be able to present to our readers an engraving produced by the use of the sand-blast, of which we have in our possession some excellent specimens. The process, which we are only at liberty to describe in general terms, consists in bringing upon a suitable matrix a photographic copy of the drawing or engraving which it is desired to reproduce. This is then passed beneath the sand-blast, and the cutting thus obtained. This is finally subjected to the electrotyping process, and any desirable number of copies thus produced.

In connection with the same invention, it may be of interest to mention that it has been successfully applied to the cleaning of brass castings in the establishment of William Sellers & Co., Philadelphia, but more especially to the decoration of marbles and other stones for ornamental purposes, at the works of Mr. Struthers. For this purpose, the blocks are protected with an open design of sheet-iron, or of sheet-rubber, and the steam sand jet directed upon them from a convenient distance.

The Isodimorphism of Certain Compounds.—The fact has long been known that the prismatic crystals of saltpetre possessed almost identically the same angles as those of aragonite; and it is equally well known that the soda saltpetre crystallizes in rhombohedrons scarcely to be distinguished by measurement from those of calcite. The fact that a well cleaned crystal of calcite would grow

when suspended in a saturated solution of the soda saltpetre, was demonstrated as early as 1854, by Senarmont, and the analogous phenomenon of the growth of an aragonite crystal immersed in ordinary saltpetre has been long well known. This curious morphological identity was regarded as being sufficient to warrant the holding of the two nitrates as isomorphous, each with the carbonate upon which it grew. Frankenheim, however, has carried the subject further, and has shown that under certain conditions the potassa salt can be obtained in rhombohedrons identical with those of calcite; thus proving the highly interesting fact, that the nitrate of potassa and the carbonate of lime are isodimorphous. It still remains to be shown that the soda salt can assume the crystal form of the rhombic aragonite to complete the last link binding together this interesting group of compounds. A careful investigation, conducted with this object in view, would doubtless prove successful in determining the necessary, but as yet unknown conditions which would bring about the desired result, while the demonstration of the fact would be of the greatest value in sustaining the theoretical considerations which in this and similar cases point to its probability.

Cyanide of Iodine in Iodine.—Dr. G. C. Wittstein has found in a sample of iodine made in the ordinary way 28·75 per cent. of iodide of cyanogen. In another sample, where the maker had tried to separate the impurity by sublimation, there was found 56·87 per cent. The mode of analysis in both cases was to rub together in a mortar weighed quantities of iodine and metallic mercury, until all the free iodine was combined; to treat the mass with water and weigh the insoluble residue. The loss of weight represents the impurity. When iodine containing iodide of cyanogen is treated with metallic iron, proto iodide and proto-cyanide of iron are formed. The addition of carbonate of potassa precipitates both all the iron and all the cyanogen, and the resulting iodide of potassium is free from cyanogen.—*Dingler's Polytechnic Journal.*

A Sensitive Test for Chloroform.—Hofmann announces* that the behaviour of chloroform towards the monamins, in the presence of alcohol and caustic soda, may be utilized with great advantage to determine the fact of its existence in small quantities, in the presence of other similar compounds. The reaction depends upon the formation of Isonitrile, which can be detected without fail by its characteristic smell. The fluid to be tested is poured into a

* Ber. d. D. Chem. Gesell, III. 769.

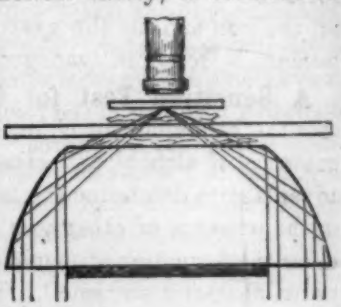
mixture of aniline and caustic soda, when, if chloroform is present, a violent reaction soon sets in, particularly on gentle heating, which is accompanied by the giving off of the characteristic smell of Isonitrile.

New Determinations of Atomic Weights.—Bunsen has recently published* the results of some investigations with a new calorimetric process, which indicate that considerable modification of certain weights and figures must be made, in order to be consistent with fact.

The specific heat of Indium was found to be 0·057. The well-known relation between specific heat and atomic weight, as expressed by the law of Dulong and Petit, furnishes the control by which the correctness of the atomic weight of Indium can be tested. The two values 37·92 and 37·07 heretofore accepted as the nearest approximation to the truth, are found by Bunsen to disagree with the law. It is necessary, according to his results, to assume the formula of the yellow-oxide of Indium to be $In_2 0_3$ instead of that heretofore accepted, In0; a process which consists practically in increasing the atomic weight of the metal by one-half. The author announces the value 56·7 for Indium, as most in accordance with his work.

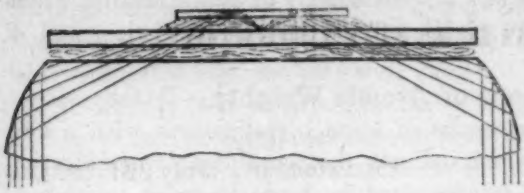
The author has likewise determined the specific heat of Calcium and Ruthenium, corresponding to the atomic weight of 52 for the former and 20 for the latter.

New Devices in Microscopy.—Dr. Barker has communicated to the Royal Irish Academy a new adaptation of the immersion principle for illuminating microscopic objects. The accompanying engravings (for which, as well as for those illustrating the following item, the *Journal* is indebted to the kindness of Dr. William Crookes) illustrates the new device. Dr. B. takes a paraboloid, which, instead of the usual hemispherical cavity, is constructed with a flat top. A thin film of water is also introduced between the paraboloid and the lower surface of the slide; thus securing optical contact between the two. The oblique rays are thus economized, while the liquid film acts as a water-joint, allowing full freedom of motion in the stage.

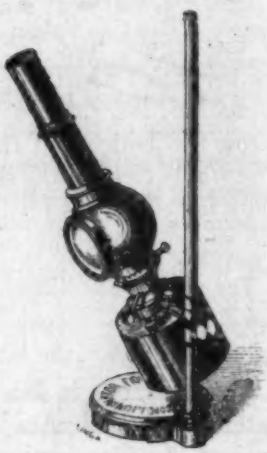


* *Pogg. Annalen.* CXLI. 1.

By making the focus of the paraboloid higher the advantage is claimed that the oblique rays will suffer total reflection from the upper surface of the covering glass, so that the object will be additionally illuminated by the reflected light.



A New Lamp for the Microscope.—The *Quarterly Journal of Science* contains, among its miscellaneous notes, an illustrated description of a new lamp, which is here briefly condensed.



The design is that of Mr. Fiddian, and seems to possess several points of advantage. The whole contrivance is intended to be portable, the enclosing case being but 6 inches high by 3 inches in diameter. Its disposition in the case is shown by the second cut. The chimney is of metal, and is jointed so that the parts may telescope into each other. The aperture is furnished with a plano-convex lens to give parallel rays. The appearance of the lamp in operation is shown in the remaining cut. It may be tilted at any angle which may be desired.

Editorial Correspondence.

PHILADELPHIA, July 22d, 1871.

Editor Journal of Franklin Institute.

DEAR SIR—Hearing of the terrible explosion of the locomotive "Vulcan," at Mauch Chunk, on Thursday, I took the train for that locality as soon as possible, but reached the scene of disaster after the forward part of the engine had been removed. This was easily done, for the boiler parted at the rear flue sheet, the forward part of the engine, head-light, stack, bell, &c., remaining intact upon the truck and first two pair of drivers. As far as I could gain information, the rupture of the rear flue-sheet was quite straight across the boiler, and the flues comparatively but little damaged. The whole force of the explosion was therefore in the fire-box, and there the effect was terrible—a total demolition of the rear part of the engine being the only way to express it. The fire-box was rent in pieces, the fractures generally following the line of rivets, but in several cases extending into the sheets, in irregular lines. The heavy braces of the crown-sheet in some cases were torn completely loose, and the whole sheet bent more than double; stay bolts were broken off and scattered in all directions. The accompanying pieces of the fire-box, etc., will give you a fair idea of the general appearance of the whole. Immediately at the fire box an axle connected the hind pair of drivers; this was broken off short against the hubs of both wheels, as if it had been cut by an immense pair of shears. The intensity of the force necessary to produce such an effect can only be imagined. One driver was, it is supposed, thrown into the river, as it had not been found. The tender of the engine was but little damaged. The only effect upon the track was the forcing outward of a couple of rails, and the bending downward and indentation of a third. The latter was evidently under one of the hind drivers; there was an indentation on its face, about 2 feet from one end, 1½ inches deep and 4 inches long, as if compressed by hammering, and the rail bent downwards considerable; the quality of the steel was shown by the fact that there was no signs of fracture.

The worst feature of the explosion is that six men lost their lives by it. They were all upon the engine, and their positions, after the accident, will show the intensity and directions of the forces. The engineer was thrown over 800 feet to the right, up a hill about 100 feet in elevation, and one limb was torn from his trunk; a brakesman was dashed against a bank about 30 feet in the same direction; the fireman was hurled to the left, across the Lehigh river, a distance of over 500 feet, and a brakesman about 150 feet in the same direction. The position of these four and the engine were nearly in a line. The two remaining brakesmen were thrown about 100 feet backward from the engine, and one of them completely stripped of all clothing.

It is evidently strange that the bodies should be thrown, two to the right, two to the rear, and two to the left. The front part of the engine ran forward some 500 feet on the track; but as at the time of the explosion it was drawing a train of cars, this might have partly depended upon the motion of the engine, or the impetus of the train, or a recoil. The cause of the explosion may remain always hidden; for such of the iron as I examined looked good. If, however, it is possible for a boiler to explode by water in a spheroidal form, being relieved from pressure, this may have been such a case. Diligent inquiry among a gang of track layers who were working in the immediate vicinity at the time of the explosion, some of whom were burned or cut by fragments, furnishes the following data.

The engine was slowly drawing a long train of empty coal cars out from a sidling, shortly after passing the gang of hands mentioned; the engineer looked back, and seeing that the hind brakesman had adjusted the switches and jumped upon the train, he gave the engine more steam, and the explosion instantly occurred.

I could gain no other information, for the only description the men in the vicinity could give was that the whole air was full of flying missiles, dust, steam, and burning coal.

Yours respectfully, JOHN BIRKINBINE.

The Sun-Spots.—Prof. Daniel Kirkwood has announced that the period of the sun-spot cycle is gradually lengthening—it being a variable and not a constant figure; and he draws from this fact the conclusion that the cause of this phenomenon is not to be sought in the influence of the planetary bodies, for this influence, being constant, would preclude any variation in its effects; but it must be sought in some purely physical cause operating upon the sun's body.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse.

(Continued from page 105.)

M. Chateaubriand, in his youth, was deeply interested in the idea of the northwest passage. He was on the point of going out in person in its search; and when he paid his visit to Washington, he discoursed with him upon this subject with great delight.*

How majestic and fair was Spain in the 16th century! What daring, what heroism and perseverance! Never had the world seen such energy, activity or good fortune. Her's was a will that regarded no obstacles. Neither rivers, deserts nor mountains far higher than those in Europe, arrested her people. They built grand cities; they drew their fleets, as in the twinkling of an eye, from the very forests. A handful of men conquered empires. They seemed a race of giants or demi-gods. One would have supposed that all the work necessary to bind together climates and oceans would have been done at the word of the Spaniards as by enchantment, and, since nature had not left a passage through the centre of America, no matter; so much the better for the glory of the human race! They would make it up by artificial communication. What, indeed, was that for men like them? It were done at a word. Nothing else was left for them to conquer, and the world was becoming too small for them.

Certainly had Spain remained what she then was, what has been in vain sought from nature would have been supplied by man. A canal, or several canals, would have been built to take the place of the long desired strait. Her men of science urged it. In 1551, Gomara, the author of the "History of the Indies," proposed the union of the oceans by three of the very same lines toward which, to this hour, the eye turns with hope.

*The interview is narrated by Chateaubriand—Œuvres Completes, tome xii. The enthusiastic traveler dined by invitation with the President, in Philadelphia, 1791. His enthusiasm prompted him to say to General Washington: "It is less difficult, sire, to discover the passage to the Indies than to create a nation as you have done." But he records in his journal that Washington replied only in French or English monosyllables—probably through his want of familiarity with the French language.

"It is true," said Gomara, "that mountains obstruct these passes, but if there are mountains there are also hands; let but the resolve be made; there will be no want of means: the Indies, to which the passage will be made, will supply them. To a king of Spain with the wealth of the Indies at his command, when the object to be obtained is the spice trade, what is possible is easy."

But the sacred fire suddenly burned itself out in Spain. The Peninsula had for its governor a prince who sought his glory in smothering free thought amongst his own people and in wasting his immense resources in vain efforts to repress it also outside of his own dominions through all Europe. From that hour Spain became benumbed and estranged from all the advances of science and art by means of which other nations, and especially England, developed their true greatness.

Even after France had shown, by her canal of the South,* that boats could ascend and pass the mountain crests, it does not appear that the Spanish government seriously wished to avail themselves of a like means of establishing any communication between her Sea of the Antilles and the South Sea. The mystery enveloping the deliberations of the Council of the Indies has not always remained so profound that we could not know what was going on in that body. The Spanish government afterward opened up to Humboldt free access to its archives, and in these he found several memoirs on the possibility of a union between the two oceans; but he says that in no one of them did he find the main point, the height of the elevations on the Isthmus, sufficiently cleared up, and he could not fail to remark that the memoirs were exclusively *French* or *English*. Spain herself gave it no thought. Since the glorious age of Balboa, among the people indeed the project of a canal was in every one's thoughts. In the very wayside talks in the inns of Spain, when a

* The Canal of the South, or Canal of Languedoc, begun in the reign of Louis XIV., and completed in the year 1668, was the first example in Europe of inland navigation on a great scale, and the most stupendous undertaking of the kind in France. Its general breadth is sixty feet, its depth, six and a half feet. It has 114 locks and sluices, and in its highest part it is 600 feet above the sea level. The canal unites Toulouse on the Garonne with the port of Cette on the Mediterranean. Its cost was 30,000,000 francs, or six millions of dollars. As a scientific work, and as one which called for such an amount of capital, it was an honor to the age that gave it birth.—(See Encyclopædia Britannica, Vol. X.) It is now proposed to enlarge the canal to the capacity of a ship canal, and thus effect a communication between the Atlantic and the Mediterranean, avoiding the passage by Gibraltar.

traveler from the New World chanced to pass, after making him tell of the wonders of Lima and Mexico, of the death of the Inca Atahualpa and the bloody defeat of the Aztecs, and after asking his opinion of Eldorado, the question was always about the two oceans and what great thing would happen if they could succeed in joining them. The Spanish government alone cared nothing for it. For years there was not one publication upon the subject which the humblest of our civil engineers would not now deem beneath his study. It became a mere idea and legend. The long wars of the Spanish monarchy and its fearful decline almost consigned the very idea to oblivion.

In the years 1520 and 1521, Cortez established a rough communication by the route uniting the Chimalapa to the Guasacoalcos. At the end of the eighteenth century, when Spain seemed to wish to awake from her lethargy, there was again some talk of a navigable communication across the Isthmus of Tehuantepec and in Guatemala by the Lake Nicaragua, but nothing of any importance resulted.

In our day, during the war between Napoleon and England, in which Spain was allied to France, the indigo of Guatemala, the most precious of known indigoes came from Tehuantepec by way of Oaxaca on the backs of mules to Vera Cruz for shipment to Europe. The cost of transporting it was thirty dollars per load of 138 kilogrammes; and the muleteers took three months for the journey, which by a straight line is not more than three hundred kilometres. To take this in French measures, it was 3.40 francs for every thousand kilogrammes. Had there been a canal in good order, the expense and time would not have been one-fourth of this.

During the whole of the seventeenth and eighteenth centuries, Spain had great need of the best mode of conveyance across the Isthmus. Yet her treasures from Peru brought by the Spanish galeons to Europe, must always be delayed by the detestable route from Panama to Porto-Belo! So, also, her merchandise from Europe for Panama must go up the Chagres River by miserable boats to Cruces, and from Cruces to Panama on the backs of mules.

Thus little did Spain do in opening up any communication within her domain of the New World. With a good system of conveyance, she might have drawn from her colonies unbounded treasures; for they were so extensive that they were but one-fourth less than half the surface of the moon, and their fertility and riches were yet more

remarkable than their extent. To act as she did in regard to intercourse, and particularly the intercourse between the two oceans, was to falsify her own interests and those of civilization. For if, in the matter of private property, ownership involves the right of neglect or abuse, it is not the same as regards civilization. By the Divine law, there is a right of confiscation against states who do not make use of the *talent* entrusted them by the Master, or who use it against the invincible tendencies to civilization which are promoted by the intercourse of continents and races. This clear law has been too often written in letters of fire and blood on the pages of history to be now possibly called in question!"

Such is the substance of Chevalier's resumé of the old Spanish rule in America, and their neglect of inter-communication between the great oceans. It has been said that the kings of Spain had the will but not the power to accomplish what they desired in this matter: that they depended upon those two old routes,—across Tehuantepec and Panama because their inability to convert them into canals compelled them to accept these. But the most charitable student of history will find himself compelled to agree with the bold protests of Chevalier. He will get the key to the whole Spanish system—to this mysterious closing up or neglect of the highways across the continent from a few paragraphe by another distinguished French author, M. V. A. Malte Brun, son and worthy successor of the great geographer. In his memoir* of a part of the same historic ground, he says,—"The aristocratic nonchalance of the Castilians, and *their fear to open to strangers* by an interoceanic canal the way to the countries they had explored for their own profit only, kept these countries shut up and unimproved. The great events which in Europe occupied Spain in the 17th and 18th centuries, suffered them to consider the rough means of inter-communication sufficient for the age. The court of Madrid, far from encouraging the carrying out of projects for easier and more rapid communication, forbade, on pain of death, the use of the plans proposed. They wronged their own colonies by even falsifying their charts, and representing the coasts as dangerous and the rivers as impassable.

In 1775, several high personages of Oaxaca presented to the Viceroy a memoir proposing to canalize the Guasacoalcos and continue the canal as far as Oaxaca by the Sarabia. An American merchant, Mr. Robinson, in his book on Mexico, tells us that he saw an old copy of this memoir in 1816. Its authors had given the

* Annales des Voyages, 6, ix-x.

topography of the Isthmus, dwelling on its beauty and fertility, and declaring the canal could be built without difficulty. They added, that if political reasons opposed this enterprise, they could tunnel the mountains and thus make another route for the home transportation, which would be available at slight expense. The memoir sent to the Spanish Government was put away in the secret archives, doomed to forgetfulness. An order was issued forbidding the subject *to be mentioned*, except by the Sovereign's permission. The impertinent innovators were censured for proposing such bold revolution within the ordinances for the government of the Kingdom. The Viceroy himself fell under the stern displeasure of the Court, for having seemed to favor the project.

Yet later, Spain fearing the enterprise of other nations interdicted on pain of death the navigation of the San Juan de Nicaragua, built a fort forbidding all access by foreign flags and obstructed the bed of the river by sunken vessels. Not until the independence of the colonies, was an engineer permitted to land on those shores or the great Isthmus to be explored. The governors of the Castle of San Juan were perpetually charged not to suffer an Englishman to reach Lake Nicaragua, for, said they, "if the English ever come to know the value of this country, they will make themselves masters of it."

It is not, however, true that no explorations were made, or knowledge of the Isthmus secured by the Spanish colonies for their own home use. Squier tells us from the Spanish and Mexican authorities, that the continent was traversed and its recesses explored; and that the lines which modern research has indicated as affording facilities for interoceanic communication did not escape the explorers. The south coast of the great Isthmus and the interior of Darien were not thoroughly explored by the Spaniards because of the political reasons already referred to, and because of the hostilities of the Spaniard. The gold mines of Darien increased the political reasons for keeping the country unknown. The errors arising out of the differences of longitude as marked upon the maps were another serious obstacle. These errors in regard to points on opposite sides of the Isthmus, really on the same meridian, misplaced them in some instances as much as thirty miles. Making allowance, however, for want of accuracy in longitude and in the coast lines, we have still reason to believe that the interior was fairly surveyed and mapped. In the valuable collection of documents made by Mr. Arrowsmith, of London, are many Spanish charts,

among which are those that show the Spanish establishments, military and religious, and their mining districts of Darien. "No survey need be better than some of the Spanish works undertaken near the end of the last and the beginning of the first century." Methods of survey and instruments were used by Tofino, Bauza, Cadova and others, which were not adopted until long afterward by English or French surveyors.

In the second edition of Admiral Davis' Report to the United States Senate, 1867, will be found an excellent fac-simile of such an old Spanish map or itinerary, dated in 1781. The Spanish descriptions of the map proved its authenticity, accuracy and value as a military report of that date. It is interesting to observe how the Spanish Governor Ariza only names the "narrow necks of land," which he has discovered, dividing such points as Caledonia on the north, from the Savana on the south or Pacific side. He dared not reveal to Spain a wish for inter-communication to be opened up. The illustrious Humboldt visited the New World as an explorer, arriving in Mexico in the year 1800. He afterward dedicated his great work on New Spain to Charles IV. in grateful acknowledgment for the access granted to him to the Spanish colonies and to the Archives of Spain. In his preface he credits this sovereign with a true interest in securing a knowledge of the colonies. He says: "The time is passed when Spain, through a jealous policy, refused to other nations a thoroughfare across the possessions of which they so long kept the world in ignorance. Accurate maps of the coasts and even minute plans of military positions have been published." Humboldt, throughout his "Essay," urges the Sovereign to the securing of still further geographical knowledge in the New World. He proposes to him the practicability of a canal and discusses the Tehuantepec, Nicaragua, Panama and Atrato routes.

No serious move, however, was made, unless we may except a single proposition made by the Cortez in 1814—a decree which stands in history as the land-mark and link between the old government of Spain and the new, as regards this matter of interoceanic communication. In 1814 the Cortez really authorized and decreed the construction of a canal across the Isthmus of Tehuantepec. But as usual with that august body "they were just in time to be too late." The revolt of the colonies was coming on. Delay *always* belonging to Spanish movements threw the decree forward within the shadow, or rather, the light of the Revolution. The

work was never to be done by Spain. Her day of opportunity was past. The semi-civilization of the Aztecs shows itself in their highways, the remnants of which outlive even the traditions of that people. But their conquerors, though able and wealthy, and possessing the resources of science for a work which would have established their empire and blessed mankind, through their narrow-minded policy added to these highways of intercourse nothing whatever of value.

(To be continued.)

ON THE FLOW OF WATER IN CANALS AND RIVERS.

By D. Farrand Henry, Ph.B.

(Late Assistant on the United States Lake Survey.)

The velocity of water in streams was probably first measured by means of bodies floating upon its surface; and even to the present time, floats are often used to determine surface velocities; although Boileau says:* "One can in certain cases obtain the surface velocity exactly by means of floats; but to obtain this exactitude a great number of often impossible conditions must be fulfilled." And after naming some of the conditions, he concludes (p. 269): "Lastly, even with floats sunk to the surface of the water, it is essential that observations be made in a calm time; for the molecules of a fluid current at the surface are so unstable that a breeze apparently insignificant causes a notable variation in the velocity." And D'Aubuisson, after describing the best kind of floats, says: "In this manner by repeating the operation two or three times, we expect to obtain the velocity of the swiftest current with sufficient exactness; but for the fillets contained between this and the sides, this mode will not answer, the float will not maintain the necessary direction."†

The double float was first constructed by Leonardo da Vinci, (though the idea is attributed to Mariotte.) It was composed of two balls of wax connected by a thread, one loaded so as to sink to the required depth; the other being partly immersed. The objections to surface floats apply with greater force to the double float, which besides has errors of its own which will hereafter be noticed.

* Traité de la mesure des eaux courants, par P. Boileau, Paris. Page 267.

† Treatise on Hydraulics, by J. F. D'Aubuissons de Voisins. Translated by J. Bennett, Boston, 1852, page 156.

In 1777, Mr. T. H. Mann, in a paper read before the British Association, recommended floating rods, loaded at one end so as to sink nearly to the bottom of the stream; the upper end projecting slightly above the surface.

These have been used by Buffon in his velocity measurements of the Tiber; by Krayenhoff in rivers in Holland; and more recently by Mr. J. B. Francis in the Lowell canals. Although more valuable than any other system of floats, they are only applicable to small streams and canals; and even then, many precautions and a large number of observations are necessary to eliminate their unavoidable errors.

The float-wheel which could be held in a current, the velocity being given by the number of revolutions it made in a certain time, is also quite ancient. It was used by Borda and by Dupuit for determining surface velocities.

The latter engineer used a fir-wheel, over two feet in diameter, having on its axle a pinion which engaged with an indexed cog-wheel by means of which the number of revolutions could be directly observed. Woltmann, in 1790, modified this meter so that it could be used beneath the surface. He constructed a helicoidal wheel, with an endless screw on its axle, and a train of two gear-wheels, so hinged to the frame of the meter, that when raised the teeth of the first wheel would engage the screw.

This meter could be run down a pole driven into the bed of the stream, a cord being fastened to an arm connected with the train, so that the gear-wheels could be raised for any required time, and thus the number of revolutions of the meter-wheel recorded. This was a great improvement on the floats, but it is liable to errors arising from the friction of the wheel on its axle, and of the recording train; from the shock the revolving-wheel receives when the train is raised; from the inertia of the gears causing them to revolve after being released; and from the retardation of the train by dirt and vegetable debris suspended in the water.

There is also great difficulty in using this instrument in deep water, as it has to be raised to be read after each observation.

Lapointe raised the recording apparatus above the surface by connecting the axle with a vertical rod by beveled gear. This, of course, obviated the difficulty of clogging the train by dirt, and of raising the meter to read the recording apparatus; but the friction was increased, and the meter could only be used in shallow water.

Baumgarten, Saxton and others have modified the form of this meter, but they have not altered it so as to materially lessen its errors.

Dr. Brewster made the axle of the meter a long fine screw; the hub of the wheel having a female screw cut in it; so that the number of revolutions were indicated by the distance the wheel traveled; and Mr. Laignel modified this meter by fixing the wheel on the screw, and indicating the number of revolutions by a nut which moved an index along a scale. A detent held the wheel in these meters until the commencement of the observations. Although the friction is much reduced in this instrument, the screw could have no great length; and the wheel must be stopped before the full distance is traveled, while the Woltmann meter may be allowed to run more than one revolution of the second wheel of the train.

Mr. Gaunthey, in 1779, invented the pressure plate, which was improved by Brunnings in his tachometer, and used by him on the Rhine; and also by Mr. Racourt in his velocity observations on the Neva. This instrument consisted simply of a disk of metal opposed to the current, the velocity being measured by the amount of weight required to keep it vertical. This meter was further improved by Capt. Boileau; but though it might determine surface velocities with considerable accuracy, it would be very difficult to manipulate in deep water, and as it only shows the velocity at the time of reading, and not the mean of the varying velocities, it would give but little better results than floats. The hydrometric tube, which was improved by Capt. Boileau, is simply a glass tube suspended horizontally in a frame, having a full size opening at one end, and a small orifice at the other. The tube is filled with water, and the large end closed; a small bubble of air being allowed to enter the orifice, and the apparatus is placed in the current, with the small end up stream. Then, opening the large end, the time required for the bubble of air to traverse the tube is noted. The velocity of the stream will be greater than the velocity of the bubble of air by the ratio of the areas of the tube and the orifice.

Besides these meters there have been many instruments proposed for the measurement of the velocity of water, such as Castelli's quadrant, which consisted of a loaded ball, connected by a thread with the centre of a graduated circle, the velocity being shown by the number of degrees the ball was carried from a perpendicular when placed in a current. Dr. Leslie proposed using a thermome-

ter; the temperature of water in motion being higher than when at rest.

Pitot's tube, which was lately improved by Mr. Darcy, is quite an accurate instrument for shallow streams. It consists of two tubes; one of which is drawn to a fine point, and bent at right angles, so that it can be opposed to the current, and the other has a hole of the same size at the lower end. The velocity is shown by the difference of the heights of the water in the two tubes, and by partially exhausting the air from both tubes, the columns of water can be raised high enough to be conveniently read. M. Darcy remarks that it will give an accurate determination of the velocity if the columns be watched for a short time, and the mean taken of the highest and lowest stages.

Among these instruments the preference is generally given to Woltmann's meter, especially in Germany; and if the friction of the parts could be reduced to zero, the danger of retardation by clogging be removed, and if it could be run for any required time at any depth, it would be a perfect instrument for the measurement of velocities.

The telegraphic meter fulfils most of these conditions, and as it was fully tested in the determination of the outflow of the lakes, and has not yet been described in any work on hydraulics, a detailed description will be given.

This meter is shown in Plate I., Figs. 3 and 4, and the register in Figs. 1 and 2; these parts being separate in this instrument.

Fig. 3 is a float meter, consisting of hemispherical cups attached by arms to an axle, which runs between adjustable pivots in a frame B. An independent short arm, C, comes in contact with the fine spiral platinum wire, D, at every revolution of the cups. This wire is insulated from the frame, and is connected with one pole of a magnetic battery, the other pole being connected with the frame, B.

At each revolution of the meter, the battery circuit is made and broken by the short arm coming in contact with the insulated platinum wire. If now a Morse's paper register be placed in the circuit, at each revolution a dot will be made on the moving paper, and the number of these dots recorded in a given time will give the number of revolutions of, and thus the distance traveled by the cups, from which the velocity of the current can be calculated. The ordinary register used is shown in Figs. 1 and 2.

This consists of a Morse sounder, the armature arm, N, being extended, and carrying an escapement which engages with the teeth

HENRY'S
Telegraphic Current Meter

Fig. 1.

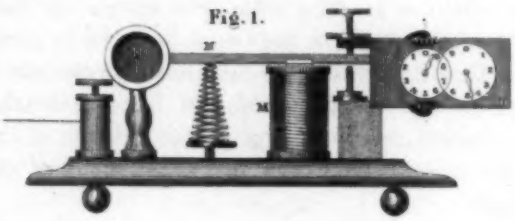


Fig. 2.

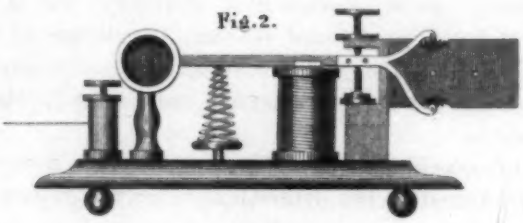


Fig. 5.

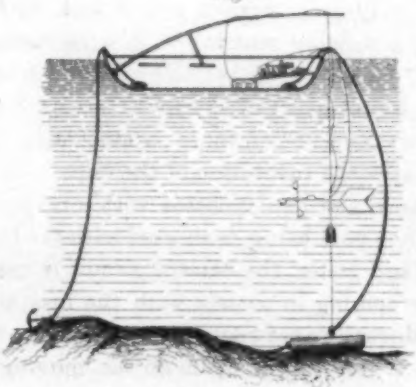


Fig. 3.

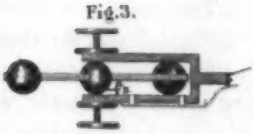
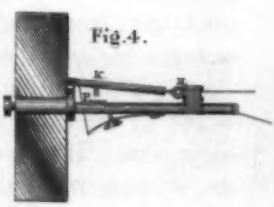


Fig. 4.



Drawn by F. Molitor C.E. Detroit, Mich.

Jos. M. Gaugler Lith. Phila.

of a wheel, G. At each revolution of the meter the armature is attracted to the magnet, M, and the escapement moves forward the wheel, G, one tooth. Any number of wheels can be geared to the wheel, G, so that the revolutions can be recorded for any required time.

Fig. 4 shows another form of meter, the wheel being helicoidal, having an eccentric on its hub, which raises the ivory arm I at each revolution. This arm has a wire passing through it, connecting with the insulated hinge H at one end, and at the other with the platinum point, P. A light spring, S, serves to keep this point in contact with a platinum plate on the axle. The hinge, H, is connected with one pole of the battery by an insulated wire, and the axle with the other pole. At each revolution the eccentric raises the ivory arm, and thus breaks the battery circuit. Both of these meters have vanes at right angles to each other, so as to keep the wheels opposed directly to the current.

The method of using this apparatus is shown in Fig. 5. A boat is anchored in the river at the place where observations are to be made. A lead weight of about 50 lbs., having a strong copper wire fastened to it, is lowered over the stern. This weight is also connected with the anchor by a rope of the proper length to keep it exactly under the stern of the boat. The spring-pole, which runs fore and aft is bent down, and the copper wire fastened to its after end. This serves to keep the wire taut, and also to take up the small motions of the boat. The yoke, in which the frame of the meter hangs, has a swivel ring at top and bottom; to the lower a weight is fastened, and to the upper a measured cord. It has also a spring-clasp which is passed over the wire. The cord has spring clips every five feet, which are also clasped on the wire to keep the cord from bowing down stream. The meter being put on the wire, it can be lowered to any required depth, the wire being connected with one pole of the battery, and the insulated wire, through the register, with the other.

By means of a switch the register can be quickly thrown in or out of circuit, without, of course, affecting or being affected by the revolutions of the meter. In the float meter, therefore, the friction is reduced to that of the wheel on the axle, and the contact of the arm with the fine spiral wire; the register being moved by an independent power, all retardation from clogging the train is obviated; and it can be run for any length of time required.

Co-efficient.—By none of these methods can the velocity be directly obtained; a co-efficient of correction being required. This can be found for meters by drawing them at different velocities through still water; by observing the number of revolutions in currents whose speed is known, and by comparison with other meters and with floats. Some engineers have thought that the relation between the number of revolutions of the meter and the velocity of the current could be expressed by the simple formula:

$v = A + B n$; in which

$v =$ the velocity of the current.

$n =$ the number of revolutions,

and A and B are constants, whose value must be determined by experiments.

M. Baumgarten and Capt. Boileau found that this relation was best expressed by a slightly curved line.

TABLE I.

Velocity in feet per sec.	Telegraphic Meter, Co-efficient.			Lapointe Meter. Co-efficient.		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
0·3	.....	14·573	.....	.....	.....	.....
0·5	12·778	12·704	+ 0·074	.....	.....	.....
1·0	11·123	11·190	— 0·067	.....	.....	.....
1·5	10·268	10·300	— 0·032	.....	0·650	.....
2·0	9·722	9·662	+ 0·060	0·571	0·572	0·001
2·5	9·208	9·208	.....	0·546	0·540	+ 0·006
3·0	8·888	8·881	+ 0·007	0·519	0·519	0·000
3·5	8·638	8·686	— 0·048	0·507	0·502	+ 0·005
4·0	8·589	8·546	+ 0·043	0·496	0·493	+ 0·003
4·5	8·504	8·518	— 0·014	0·486	0·485	+ 0·001
5·0	.....	.....	.....	0·477	0·480	— 0·003
5·5	.....	.....	.....	0·474	0·478	— 0·004
6·0	.....	.....	.....	0·466	.....	.....
6·5	.....	.....	.....	0·469	.....	.....
7·0	.....	.....	.....	0·473	.....	.....
8·0	.....	.....	.....	0·469	.....	.....
Sums...	.....	× 0·015	.....	.....	.....	+ 0·007
Mean..	.....	× 0·0017	.....	.....	.....	+ 0·0009

In Table I. are given the observed and computed co-efficients for the telegraphic meter, of the form shown in Fig. 3, and for Lapointe's meter; the observed co-efficients of the latter being taken from Morin's *Hydraulique*, page 100. The co efficient of the latter

was obtained by placing the meter in the centre of a tube between two reservoirs, and noting the number of revolutions made during the time the lower reservoir was being filled.

The observed co-efficient for the telegraphic meter was found by hanging it beneath a boat drawn through still water at different velocities, dividing the distance passed over by the number of revolutions, and grouping the results for every half a foot per second of velocity.

These co-efficients decrease rapidly in the low velocities, and more slowly in the higher. They plot in a curve which approximates closely to an ellipse whose axes are 8·28 and 3·44.

The vertex of the curve is taken at zero of the meter, or the velocity of the current at which it stops revolving. The computed co-efficients in the table are the ordinates of the ellipse, taken at every half foot per second. The difference between these and the observed co-efficients is quite small.

In the Lapointe meter the curve only goes to the velocity of 5·5 feet per second, while the observations were taken up 8·0 feet per second.

The co-efficients beyond the curve differ so little from those at 5·5 feet that they seem to be best expressed by a straight line tangent to the ellipse at that point.

As has been mentioned, the telegraphic meter used in these experiments was made with hemispherical cups, and was, in fact, constructed from a "Robinson's Anemometer.

The ratio of the resistance of a sphere to that of its great circle when drawn through still water is given by Dubuat as 35 to 100; and Beaufoy, with velocities from two to twelve feet per second, made it 342 to 1000.

Robinson's Anemometer was based on these experiments, the velocity of the cups being estimated at one-third that of the wind. Taking the mean of the whole of the above observations, the velocity of the cups is 0·36 of the velocity of the water; but at 4·5 feet per second it is only 0·189; therefore the velocities given by this anemometer are too small when there is more than a light breeze blowing.

The slight difference between the above mean ratio and that found by Dubuat and Beaufoy, shows how little friction there is in this meter, particularly when the resistance of the arms is taken into account; and, in fact, there are no recorded observations of a meter turning at so low a velocity as three-tenths of a foot per second.

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. RICHARDS, M. E.

(Continued from page 26.)

IN a previous article in this series, it was stated that wood cutting machines had not received the attention that their importance demanded, and that, as a branch of mechanical engineering, the art had, for some reason, never engaged the attention of our skilled mechanics.

This was some fifteen months since, and now, in that short time, the improvements in wood machines have been such that we would almost ask to reconsider the statement. Perhaps the neglect noted was one of the conditions that now contributes to the rapid improvement in tools of this class during the time. The English scientific journals have, during the past year, devoted more attention to wood tools than at any previous time, and the "art" (in England, at least,) is now in a fair way to reach the point of perfection attained in metal working machines, within a period much shorter than served to give a fixed or standard construction to lathes, planing, drilling and slotting machines, &c.

In fact, time is no longer an element in machine improvement. Experiment is continually giving place to mathematics, and the better understanding of laws that underlie the whole system of machine making and machine adaptation.

The plan was, in these articles, to notice, consecutively, the different classes of wood machines somewhat in the rank of their importance, but improvements have "overtaken us," and it will be necessary to return to the beginning, and notice some band-sawing machinery manufactured by Messrs. Allen Ransome & Co., of London, England, represented in the engravings.

Fig. 1 is a front, and Fig. 2 a side elevation of the mill, drawn to a true scale of $\frac{1}{24}$th. To our engineering friends these very excellent engravings need but little explanation, the several parts being all shown in a clear manner by the two views in flat elevation.

The table, or carriage, is of wrought iron, to secure against danger of breaking in turning and loading logs. The forward feed is graduated from six to twenty feet per minute. The return or gig back motion is constant at eighty feet per minute. The wheels are

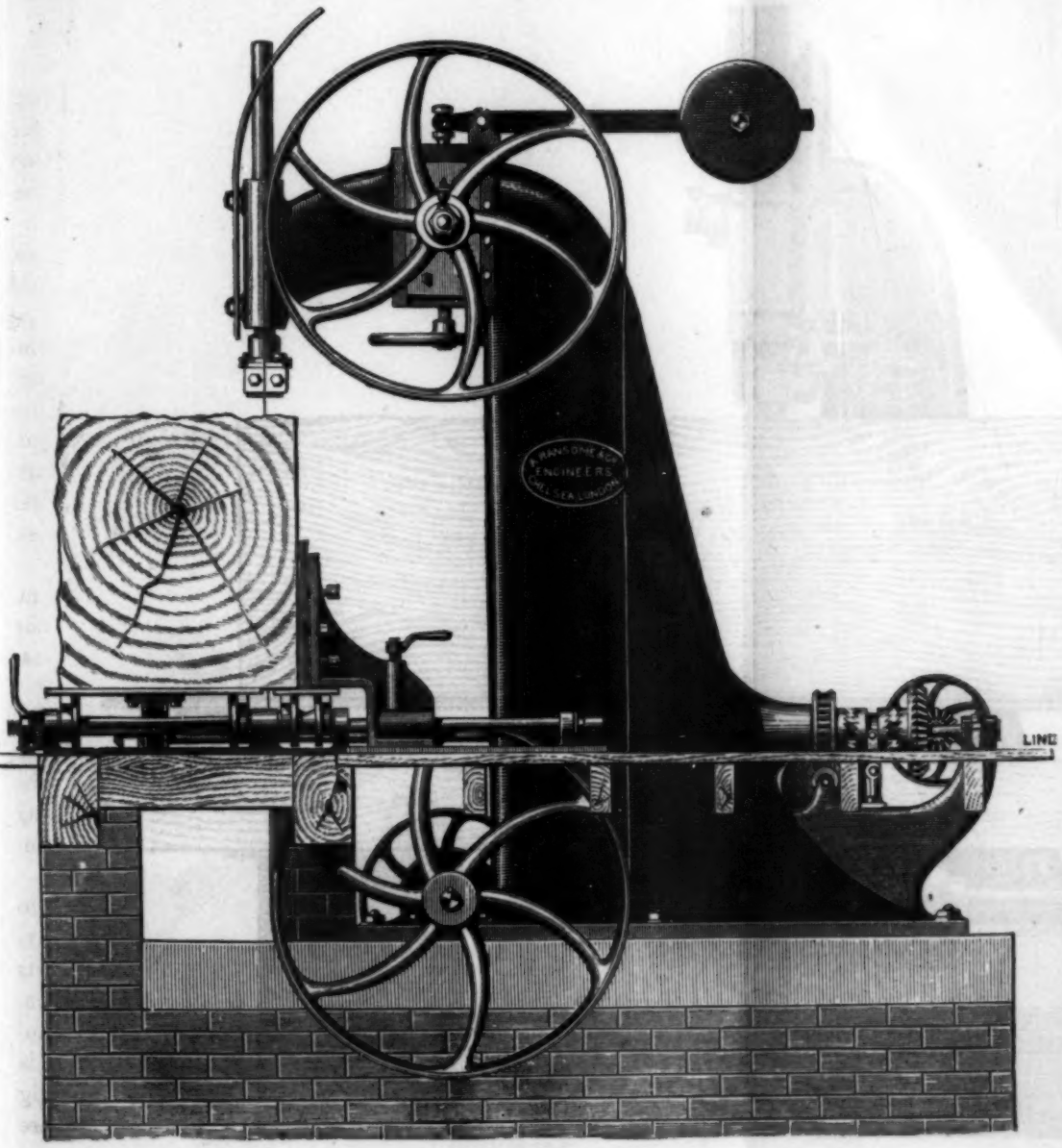


Fig. 1.

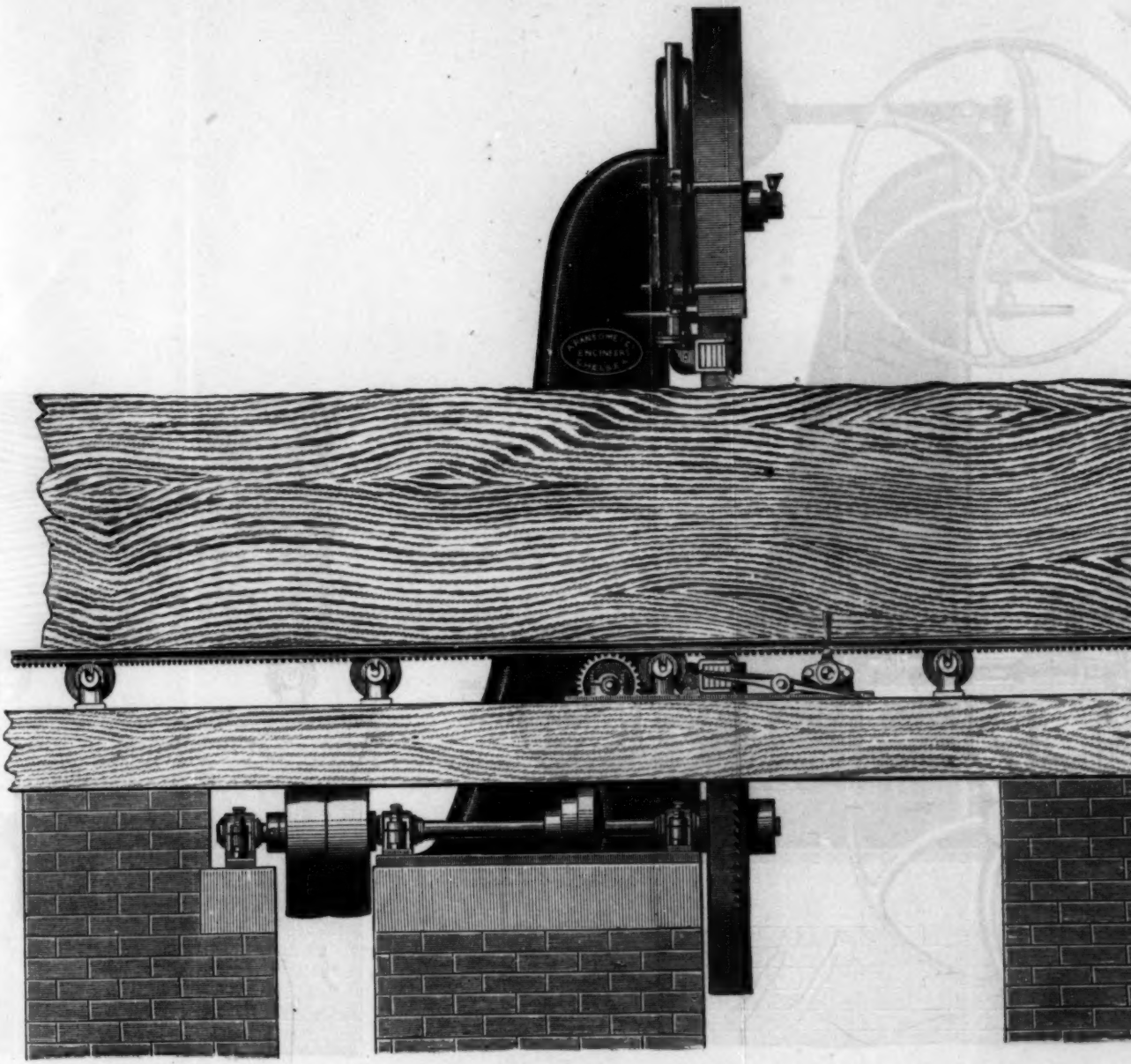


Fig. 2.

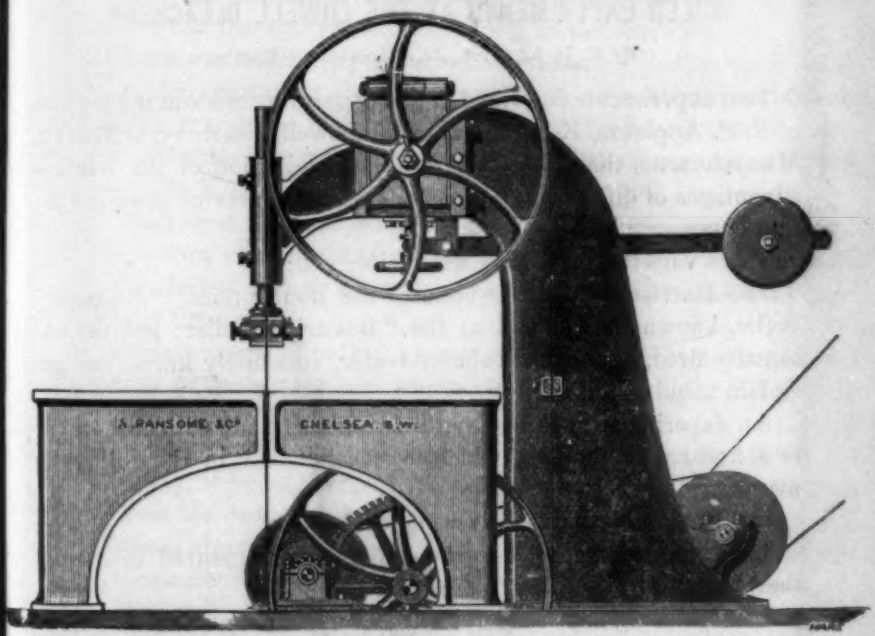
VII.

54 inches diameter, length of blades 28 to 30 feet, with a width of from three to five inches; the gauge from 14 to 18 (Birmingham); kerf $\frac{1}{12}$ inch average. The mill receives timber to 36-inch diameter and 30 feet long. The weight is ten tons.

The design is, we need hardly say, a good one. Band sawing machinery requires to be strong and heavy in all parts where rigidity is admissable, especially in all parts that give lateral support to the blades, and in the timber supports. The lineal tension on the blades is regulated by elastic or yielding mechanism, which, in this case, is by means of weighted levers acting on the adjusting screw of the top wheel.

The engraving, Fig. 3, is a true elevation, on a similar scale, of a machine built by the same makers, for "cutting metal," and al-

Fig. 3.



though this use of the band saw is a recent one, it gives promise of high results. A saw can be operated for four hours in iron that is comparatively "clean," without sharpening, cutting from two to three superficial inches of section per minute, or will do twice the same amount in common brass, with a movement of 300 feet per

minute of the blade. The general construction is the same as in the machine shown in the plate at Figs. 1 and 2, with the difference of the reducing gearing seen at the back of the column. The weight is three and one-half tons.*

The manufacture of blades, which has heretofore been confined to France, mainly, at least, will no doubt soon be successfully carried on in England and the United States. The late European war, for a time, so deranged the commerce and manufacture in Band Saw blades, that the manufacture of machines has not progressed so fast as it otherwise might; still, it goes steadily on, and the end of the Band Saw is not yet.

(To be continued.)

BOILER EXPERIMENTS AT THE LOWELL BLEACHERY.

By E. D. Leavitt, Jr., Mechanical Engineer.

The experiments described in this paper were made at the request of F. P. Appleton, Esq., Agent of the Lowell Bleachery, at Lowell, Massachusetts, the object being the determination of the relative advantages of different types of boilers for the service required by that company.

Three varieties of boilers were tried, viz.:

The Harrison cast-iron boiler; the double-flued "Hognose" boiler, known in England as the "Butterly" boiler; and the externally fired, cylindrical tubular boiler, commonly known as the "plain tubular boiler."

An experiment of three days duration was made with each of the two first-named boilers, which was conducted in the following manner, viz.:

1. The coal was carefully weighed.

2. The water supplied to the boilers was measured in a tank that was uniformly filled to a certain height.

The following data were recorded every half hour, from 5 A. M. to 6 P. M., observations being made at intervals of fifteen minutes, and the mean of two observations entered on the record, viz.:

3. The pressure of steam, as indicated by the gauges attached to the boilers.

* The ton, as given in estimating the weight of the machines of Messrs. Ransome & Co. is the English ton of 2240 pounds.

4. The temperature of the steam issuing from the boilers, which was obtained from a thermometer inserted in the main steam pipe, near its junction with the steam-drum.

5. The temperature of the feed-water entering the boilers, taken from a thermometer inserted in the feed pipe.

6. The temperature of the water taken from the tank.

7. The temperature of the atmosphere in the shade.

8. The temperature of the fire room, near the boilers.

9. The force and direction of the wind.

10. The state of the weather.

a. The temperature of the flues leading from the boilers to the chimney was frequently observed.

b. The wood used in kindling fires was weighed.

To insure results that might be depended upon for continuous service, care was taken that all the details connected with the management of the boilers should conform to the usual routine.

There was necessarily considerable variation in the water level of the boilers during the experiments, on account of intermittent feeding, which the tank measurement rendered unavoidable; it is not probable, however, that much, if any loss of economy resulted from this fact.

Fresh fires were started every morning during the experiments, which were burned out after the day's work was done; the furnaces being cleared of their contents of ashes, clinkers and unburned coal during the night.

Boilers operated in this manner will not give as high evaporative results as those that are worked continuously night and day, or those in whose furnaces the fires are banked at night. It was stated that the plan followed had proved the most advantageous for the company, it being necessary to have the best of clean bright fires to meet the demands for steam in the early part of the day, and personal observation during the experiments was confirmatory of the statement.

Care was taken to observe whether the steam supplied by the boilers was dry or charged with moisture; it was impossible, however, to reach a satisfactory conclusion on this point. There were evidences at times of the presence of water in the steam drum of the Harrison boilers, and the steam thermometer attached to the flue boilers indicated an average temperature of $6\frac{1}{2}$ degrees below that due to the average pressure as given by Regnault's tables; this

was in a measure accounted for by the fact that the steam-pipe in which the bulb of the thermometer was inserted was too small to transmit the volume of steam (generated by the flue boilers) without considerable wire-drawing; while the steam gauge was connected directly with the steam drum, and probably indicated a somewhat higher pressure than was contained in the pipe.

In the experiment with the tubular boilers the steam generated by them, together with that from six other boilers, was used by an engine of 400 H. P., the action of which gave no evidence of the passing over of water with the steam.

The steam thermometer attached to the Harrison boilers was broken by water the first night of the trial; the first day's record gave a mean temperature $5\frac{31}{100}$ degrees above that due to the pressure according to Regnault's tables. It is not certain that the thermometer was correct, as it was not compared with the standard previous to the trial, and its breakage precluded any such comparison subsequently.

The Harrison boiler experiment commenced at 6.30 A. M., September 13th, and ended at 6.30 A.M., September, 16th, 1870.

The Flue boiler experiment commenced at 6.30 A. M., September 20th, and was concluded at 6.30 A. M., September 23d.

A summary of the results obtained, together with the leading dimensions of the boilers, arranged in parallel columns for comparison, is as follows, viz.:

Summary, etc.	*Harrison Boilers.*	*Flue Boilers.*
Date of experiment.....1870	Sept. 13th to 16th.	Sept. 20th to 23d.
Duration of experiment.....	3 days.	3 days.
Number of boilers tried.....	2	3
Size of the boilers.....	50 H. P.	4 ft. dia. x 30 ft. long.
Aggregate H. P. of boilers tried.....	100 H. P.	100 H. P.
Total grate surface of "	92 sq. feet.	48 sq. feet.
" fire " "	1500 sq. feet.	948 sq. feet.
Ratio of heating surface to grate surface.....	28·85 to 1.	19·75 to 1.
Mean pressure of steam observed....	60·9 lbs.	63·32 lbs.
Mean temperature of steam (Fahr.) observed.....	*313·31°	303 69°
Mean temperature of steam (Fahr.) by Regnault's tables, for the pressure observed.....	308·03°	310·2°
Mean temperature of water in tank	67·27°	65·86°
Mean temperature of feed water entering boilers.....	144·91°	135 89°
Mean temperature of the atmosphere in the shade.....	70·22°	65 85°

*One day.

SUMMARY, ETC.	*Harrison Boilers.*	*Flue Boilers.*
Mean temperature of fire room.....	91·93°	93 09°
Direction and force of the wind.....	Variable and Light.	Variable and Light.
State of the weather.....	Fair.	Fair.
Total quantity of water evaporated during trial, in pounds.....	116604	99687
Total quantity of coal consumed during trial, in pounds.....	16125	14187
Ashes and clinkers in the coal, lbs....	1552	1284·5
" " " " per ct.	9·62	9·04
Water evaporated by one pound of coal, from temperature of feed, lbs.	7·23	7·03
Equivalent evaporation from and at 212°..... .... pounds	7·95	7·8
Relative economy of the boilers	101·9	100
Relative quantities of water evaporated by the boilers in equal times or steaming efficiency.....	117	100

The temperature of the flue leading from the Harrison boilers varied from 299° to upwards of 600°; the heat was sufficient to break a thermometer graduated to 620° on the first day of the experiment, and subsequently to melt lead.

The temperature of the flue leading from the Hognose boilers ranged between 310° and 510°; usually 420° was the highest indication.

Neither set of boilers had a first-rate draft, and one seemed to operate against the other, so that the ash-pit doors of the Flue boilers had to be partially closed most of the time.

The coal used during all the experiments was Cumberland of excellent quality, burning clean and clear, with less than ten per-centum of incombustible matter.

For the purpose of comparison with the results obtained from the experiments made with the tubular boilers, February 17th and 18th, 1870, a corresponding set of experiments were made with the Harrison and Hognose boilers, as follows.

At or soon after the commencement of work on the morning of each day (that the boilers were under trial) the fires were carefully examined and their condition noted. Late in the afternoon the fires were brought to an equally good condition, (as far as careful observation could determine) and the interval between the observations was taken for the duration of the experiment.

The data for these experiments were (in the case of the Harrison and Hognose Boilers) obtained from the daily record referred to at

the beginning of this paper; these experiments being carried on simultaneously with those first described. In the tubular boiler experiments the only data recorded were the weights of water and coal, the temperature of the feed water and the pressure of steam. The weather at the time was cold and stormy, with strong winds, so that the outward circumstances of the trial were not as favorable as in the case of the other boilers.

The results obtained from these experiments stand as follows, viz.:

Type of Boiler.	*Harrison.*	*Hognose.*	*Tubular.*
No. of experiments tried	3	3	2
Aggregate duration of experiments, in hours	24·87	26·25	18·5
Mean pressure of steam, in pounds	62·78	64·89	63 43
Mean temperature of feed water	145·08°	134·49°	69·87°
Pounds of water evaporated	88164	79008·6	92586·6
Pounds of coal burnt	9502	8730	9195
Water evaporated by each pound of coal, from temperature of feed, in pounds	9·28	9·01	9·98
Equivalent evaporation from and at 212° in pounds	10·2	10·01	11·8
Relative economy of boilers	102	100·1	118
Relative steaming efficiency of boilers	108·35	100	166·2
Coal burned per square foot of grate per hour, in pounds	7·35	7·05	10·51
Water evaporated per square foot of fire surface, per hour, in pounds	2·36	3·19	2·53
Grate surface, aggregate square feet	52	48	48
Fire " " " "	1500	948	1985·1
Ratio of fire surface to grate, square feet	28·85 to 1	19·75 to 1	41·3 to 1

The capacity of the tank was found by weighing the quantity of water that was required to fill it to the gauge mark, the temperature of the water being observed and corrections made for any differences of temperature during the experiments.

The steam gauges were tested at the close of the experiments by the American Steam Gauge Co., and the thermometers by Huddleston, the well known maker, (both of Boston) and corrections were made for each observation recorded to bring it to the standard, as shown by the tests.

In the experiment with the Tubular boilers the gauges were reported correct, having been recently tested. No additional test was therefore made at the conclusion of the experiments.

Cambridge, July 11th, 1871.

ON THE SOLUTION, MAINLY BY THE AID OF GRAPHICAL CONSTRUCTION, OF A PROBLEM IN PRACTICAL HYDRAULICS.

By Clemens Herschel, C. E.

(Continued from page 61.)

Another formula by which to get the discharge after 11h. 10m. A. M., would be (see the longitudinal section of the sluice, Fig. 2,) to consider the efflux as composed of two parts, the first part to be the discharge through the area $L h_2$, in which L is the width of the sluice, and h_2 the depth of water in the downstream end of it, under a head equal to h_1 (see Fig. 2), and the second part to consist of the discharge of the height h_1 as acting over a weir whose length is L, and with a depth on the weir equal to h_1. In this first trial, the correction of the error named was not made, as the trial was only preliminary, and resulted in the rejection of the assumed cross-section; it was applied, however, in the subsequent trials.

The second trial was made with a cross-section 9 feet 7 inches horizontal by 7 feet vertical, taking again the effective cross-section to be 1 foot less in width, *i. e.*, 8 feet 8 inches by 7 feet, and with the bottom again on grade —4, (see Fig. 2, cross-section 2,) and, starting as before with the opening of the gates at 9 A. M., the water standing on the inside on grade 5·40.

The results of the partial or differential calculations, made in the same manner as previously described, and with the formulæ above given, that is $Q = A\sqrt{2gh}$ until the water leaves the top of the sluice on the inside, and thence with the two formulæ: $Q = 0{\cdot}315^*\ L H \sqrt{2gH}$† and $Q = Q_1 + Q_2 = L h_2 \sqrt{2gh_1} + 3{\cdot}33\ L h_1^{\frac{3}{2}}$‡ are given in Table II., and also shown on the diagram, [see Table II.]

It will be observed that it so happens that the two last given formulæ attain precisely the same final result; the gates closing at 3·30 P. M., with the water on the inside standing on grade 2·12.

It might seem then that the trial section just investigated also,

* The co-efficient 0·315 is selected corresponding to that depth on the weir of Table 42 Lesbros' Exper. Hydr., which has the same proportion to the length of the weir used by Lesbros that the depths found in our case bear to the length of our weir.

† H in this formula $= h_1 + h_2$ in the next, for the meaning of which see above.

‡ From J. B. Francis' experiments on weirs without side contraction, and near enough applicable for our case.

TABLE II.

[Upper line-and-dot Curve on the Diagram.]

Time of the beginning of the several intervals or differentials of time		Time of the ending of the several intervals or differentials of time.		Height of the water on the outside during this interval from the adopted tidal curve.	Height of the water on the inside at the beginning of this interval using the formula:			Difference of level between the water on the outside and inside acting during this interval; the height on the inside having been determined by formula of the preceding column.			Mean velocity of efflux during this interval	REMARKS.
					$Q = A\sqrt{2gh}$ (a.)	$Q = 3{\cdot}15\ LH\sqrt{2gh}$ (b.)	$Q = Q_1 + Q_2 = Lh_2\sqrt{2gh_1} + 3{\cdot}33\ Lh_1^{\frac{3}{2}}$ (c.)	(a.)	(b.)	(c.)		
A. M. or P. M.	Hour & Min.	A. M. or P. M.	Hour & Min.	On grade.	On grade.	On grade.	On grade.	In ft.	In ft.	In ft.	Ft. per sec.	
A. M.	9·	A. M.	9·	5·40	5·40	Top of the sluice under water.	Top of the sluice under water.	0·34	.....	.....	4·677	The tide gates open at this Inside H. W. [time.
"	9· *	"	9·30	5·06	5·40			0·92	.....	.....	7·693	
"	9·30	"	10·	4·40	5·32			1·33	.....	.....	9·249	
"	10·	"	10·30	3·75	5·08			1·59	.....	.....	10·113	*
"	10·30	"	11·	3·17	4·76			1·77	.....	.....	10·670	
"	11·	"	11·30	2·62	4·39			1·79	.....	.....	10·780	Max. velocity of efflux.
"	11·30	M.	12·	2·20	3·99			1·67	.....	.....	10·364	
M.	12·	P. M.	12·30	1·92	3·59			1·41	.....	.....	9·523	
P. M.	12·30	"	1·	1·80	3·21			1·19	.....	.....	6·621*	At the beginning of this interval the inside water level falls below the top of the sluice.
"	1·	"	1·30	1·68	2·87			.....	1·10	1·03	6·539	
"	1·30	"	2·	1·60	Water level below the top of the sluice.	2·70	2·63	.....	1·00	0·89	6·461	Low tide.
"	2·	"	2·30	1·54		2·54	2·43	.....	0·75	0·62	6·386	
"	2·30	"	3·	1·64		2·39	2·26	.....	0·38	0·28	6·316	
"	3·	"	3·30	1·87		2·25	2·15	.....	.....	.....	.....	
"	3·30	"	4.	2·35		2·12	2·12	.....	.....	.....	.....	Inside L. W. the tide gates close at *beginning* of this interval.

* This, and succeeding values, derived from the discharges according to formula (*b.*)

was larger than necessary. Before discarding it, however, it was subjected to a different trial, to wit: to start with the water in the river at about where this left off, the rain and freshet being still supposed to continue. This investigation gives the curve 2′, from which it appears that the gates will open at 10 A. M., the water then standing on the inside on grade 4·27.

Table III. gives the results of the partial calculations for this curve, beginning at 10 A. M., the time of the opening of the gates, as it will not be necessary to repeat the manner in which the first part, the straight line, of this curve was determined. The formula $Q = 0{\cdot}315\ L\ H\ \sqrt{2\ g\ H}$ alone was used in the determination of the final portion of this curve for which see the diagram.

The result of this trial, then, is that the sluice selected will just about maintain the same low water level on the inside in times of freshet and rain storms for days in succession, and in the times between two consecutive stages of inside low water, the level of inside high water will not attain a greater height than within about 1 foot 6 inches of marsh level. This satisfies all the conditions of duty presupposed and was therefore the adopted size and position for the sluice.

For the sake of completeness, however, the calculations have been made for a sluice having a height of 5 feet 4 inches, and width of 7 feet 6 inches equal 40 square feet in section, (see Fig. 2, cross-section 3,) with the bottom on grade —2·58. The results indicating that this section is too small for our purpose are shown on the diagram by the two line-and-two dot curves 3 and 3′.

As a final result, we have, then, that the diagram and table show on inspection, any and all the principal circumstances attendant upon the proposed drainage under the conditions presupposed, and these of course can be varied to meet any desired requirements.

In certain cases, such, for example, as the drainage of low lying districts of towns along the sea-shore (there are some in this neighborhood thus built on reclaimed marsh) the value of the land may be such that it might be preferable to build larger sluices or more of them, and allow for a smaller area of river-bed, or gathering reservoir behind the same; or it may, in other cases, be advisable to intercept some of the river water or of the surface drainage before it enters the confines of the marsh, thereby decreasing the quantity of fresh water drainage to be provided for. It will readily be seen how these and other projects can be fully investigated and their

* This, and succeeding values, derived from the discharges according to formula (b.)

TABLE III.

[*Lower line-and-dot Curve on the Diagram.*]

Time of the beginning of the several intervals or differentials of time		Time of the ending of the several intervals or differentials of time.		Height of the water on the outside during this interval from the adopted tidal curve.	Height of the water on the inside at the beginning of this interval using formula:		Difference of level between the water on the outside and inside acting during this interval in feet.	Mean velocity of efflux during this interval in feet per second.	REMARKS.
					$Q = A\sqrt{2gh}$.	$Q = 0{\cdot}315\ L.H.\sqrt{2gH}$			
A.M. or P.M.	Hour & Min.	A.M. or P.M.	Hour & Min.	On grade.	On grade.	On grade.			
A.M.	10·	A.M.	10·	4·27	4·27	Top of the sluice under water.	0·	.....	The tide gates shut at this
"	10·	"	10·30	3·75	4·27		0·52	5·783	Inside H. W. [time.
"	10·30	"	11·	3·17	4·13		0·96	7·858	
"	11·	"	11·30	2·62	3·88		1·26	9·003	
"	11·30	M.	12·	2·20	3·57		1·37	9·387	Max. velocity of efflux.
M.	12·	P.M.	12·30	1·92	3·24		1·32	9·214	At the beginning of this interval the inside water level falls below the top of the sluice.
P.M.	12·30	"	1·	1·80	2·92		1·12	6·646	
"	1·	"	1·30	1·68	Water level below the top the sluice.	2·74	1·06	6·559	
"	1·30	"	2·	1·60		2·57	0·97	6·476	
"	2·	"	2·30	1·54		2·42	0·88	6·401	Low tide.
"	2·30	"	3·	1·64		2·28	0·64	6·331	
"	3·	"	3·30	1·87		2·15	0·28	6·265	
"	3·30	"	4·	2·35		2·03	.....	.....	Inside low water; the tide gates close at the beginning of this interval.

relative values determined by means of calculations similar to the above.

The solution of the problem as hitherto followed, besides neglecting several means of closer approximation which have been pointed out as they occurred is based on the crude assumption that the tide falls by steps at intervals of half an hour.

By taking the intervals of time sufficiently small, the method already given can of course be made to attain any desired degree of accuracy; but it is not, theoretically, a very perfect, and is a laborious way of reaching the desired end. A more perfect way, theoretically, and, moreover, a practical one, would be as follows; and in this also, the intervals of time may be taken shorter or longer, thereby more or less approaching the true data of the problem; with this distinction, however, that with the method now to be described an interval of half an hour for the partial calculations, will cause the probable error to be found in the data of observation and in the fundamental formulæ [formula (*a*), (*b*), &c.], rather than in the the method of calculation; a further degree of accuracy in the latter is therefore of no use, so long as the data of observation and the formulæ (*a*), (*b*), &c., are not more perfect.

The more exact calculation is as follows: divide the tidal curve into straight lines between the half hour verticals, which is to say, take the tide as falling uniformly during the consecutive half hours. An inspection of the curve will show to what slight errors this will lead. Passing now to algebraic symbols and the calculus we shall have,—in the first place again assuming that the level of the water on the inside remains constant for the half hour,—the head on the orifice of discharge at the beginning of the outflow to increase *uniformly* during the 1800 seconds, from h_1 to h_2.

By formula (*a*) the discharge at any time during this interval will be—

$$Q_y = A\sqrt{2g}\, b^{\frac{1}{2}} x^{\frac{1}{2}}, \qquad \text{in which}$$

b = the increase of the head in feet per second.

x = the number of seconds after the time when the head = o, that Q_y is taken, $\therefore b x = h$, and the meaning of the other letters is as before.

The discharge for the half hour will be—

$$Q_t = \int_{t_1}^{t_2} A\sqrt{2g}\, b^{\frac{1}{2}} x^{\frac{1}{2}}\, dx = A\sqrt{2g}\, b^{\frac{1}{2}} \frac{2}{3}\left(t_2^{\frac{3}{2}} - t_1^{\frac{3}{2}}\right), \qquad (1.)$$

t_1 and t_2 being the number of seconds after the time when the head $= 0$, which are requisite for the attainment of the heads h_1 and h_2 found at the beginning and ending of the half hour. It will be more convenient for our purpose to have the formula expressed in terms of h_1 and h_2, which may be done as follows:

$b = \frac{h_2 - h_1}{1800}$ from its definition.

$$t_2 = \frac{h_2}{\left(\frac{h_2 - h_1}{1800}\right)} = \frac{1800\, h_2}{h_2 - h_1}.$$

$$t_1 = \frac{h_1}{\left(\frac{h_2 - h_1}{1800}\right)} = \frac{1800\, h_1}{h_2 - h_1}.$$ Substituting these values in equation (1) it becomes—

$$Q_t = A \sqrt{2g}\, \frac{2}{3} \left(\frac{h_2 - h_1}{1800}\right)^{\frac{3}{2}} \left[\left(\frac{1800\, h_2}{h_2 - h_1}\right)^{\frac{3}{2}} - \left(\frac{1800\, h_1}{h_2 - h_1}\right)^{\frac{3}{2}}\right]$$

which multiplying and dividing by $\frac{h_2 - h_1}{1800} =$

$$A \sqrt{2g}\, \tfrac{2}{3}\, 1800\, \frac{h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}}}{h_2 - h_1}, \quad . \quad . \quad . \quad . \quad \text{(A.)}$$

In the case of the "weir prolonged on the down stream side by an open rectangular canal of the same width as the weir," we shall find in the event of a variable depth of water on the weir:

$$Q_t = \int_{t_1}^{t_2} 0{\cdot}315\, L \sqrt{2g}\, b^{\frac{1}{2}}\, x^{\frac{1}{2}}\, dx = 0{\cdot}315\, L \sqrt{2g}\, b^{\frac{1}{2}}\, \tfrac{2}{5}\, (t_2^{\frac{5}{2}} - t_1^{\frac{5}{2}}),$$ and this by a reduction similar to the preceding one.

$$= 0{\cdot}315\, L \sqrt{2g}\, \frac{2}{5}\, 1800\, \frac{H_2^{\frac{5}{2}} - H_1^{\frac{5}{2}}}{H_2 - H_1}, \quad . \quad . \quad . \quad . \quad \text{(B.)}$$

The use of the formulæ (A) and (*b*) instead of (*a*) and (*b*) will result in a greater approximation to the true results which we will call the *second* approximation; a still greater degree of accuracy could be obtained by taking into account the diminution of the head, respectively, depth upon the weir, caused by the inside water level falling during the half-hour and this will bring into use both formulæ (A) and (B), in the following manner. If

A_R = the proper area between the river banks and R_t = the corresponding rise in feet during the interval, due to the freshet and rainfall.

$\frac{Q_t}{A_R} - R_t$ = the amount in feet that the inside water level will have fallen during the interval = F.

After having made the calculation for the one interval under consideration, on the assumption that the inside water level remains constant, that is, that the head varies uniformly from h_1 to h_2, it is to be made again supposing now, which is very nearly correct, that the head varies uniformly from h_1 to $[h_2 - F]$, which method we may call the *third* approximation. It is not easy to suppose a case in practice with greater accuracy than the just described calculations will give, would be required, and, as before mentioned, should such a case occur a first step towards its solution must be a greater degree of accuracy in the data of the observations and the empirical formulæ to be primarily applied.

As a measure of the change produced in the results by the use of the second and third approximations,—the second implying the use of formula (A), and the third that of formulæ (A) and (B), the curve 2′ of the diagram has been recalculated according to both these methods, and the results have been plotted by points enclosed in circles giving the curves $2'_2$ and $2'_3$; they are given numerically also by the values of the ordinates of these curves as found in Table IV.

TABLE IV.

At		When calculated according to the			Remarks.
		First.	Second.	Third.	
A. M. or P. M.	Hours and Minutes.	Approximation, the water stands on the inside on grade.			
A. M.	10·30	4 13	4·15	4·16	
"	11·	3 88	3·90	3·94	
"	11·30	3·57	3 60	3·66	
M.	12·	3 24	3·27	3·35	
P. M.	12·30	2 92	2·95	3·04	The water stands on grade 3, that is, the sluice is just full, at 12 h. 34 m. in the case of third approximation.
"	1·	2·74	2·77	2 84	
"	1·30	2·57	2·60	2 67	
"	2·	2·42	2·45	2·52	
"	2·30	2 28	2 31	2 38	
"	3·	2·15	2·18	2 25	
"	3·30	2·03	2·06	2·13	

It is but just to say that although the differences of the resultant inside water levels are small in the present case owing principally to the *large* area of river bed as compared with the quantity of fresh water inflow, yet they may be found to differ seriously in other cases, where this area is proportionally smaller.

Boston, March 15th, 1871.

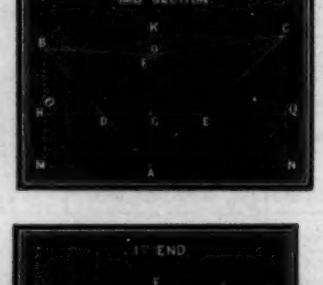
FORMULÆ, RULES AND EXAMPLES OF COMPUTATION FOR SOME OF THE MOST USEFUL CASES OF EARTHWORK UNDER WARPED AND PLANE SURFACES.

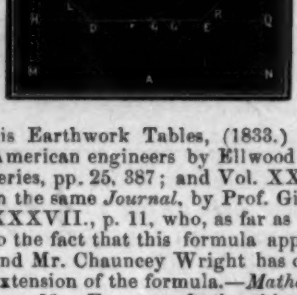
By JOHN WARNER.

(Continued from Vol. LXI., page 39.)

*Derivation of Formulæ.**—We shall compute by the prismoidal formula, which is—

$$V = \frac{L}{6}(A' + 4A + A'') \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.\dagger)$$





Referring first to the mid cross-section, we consider its whole area to be composed of the areas of four triangles G B D, G B F, G C F, G C E. These areas may be computed together in pairs. Because the two external triangles G B D, G C E, have equal bases G D, G E, they may be computed as one triangle. Keeping this in mind and repeating the same process for each cross-section successively, we shall find—

* The reader will please make the following corrections in the first part of this paper:—Page 397, line 13 from bottom, for distances read distances out; page 399, line 3 and 5 from bottom, for A N read A C; and bottom line, for σ' read σ; page 400, line 3 from top, for σ read σ'.

† This may be viewed as a particular case of a more general formula, derived by integrating the expression for the differential of a solid generated by the motion of its cross-section. Our formulæ may therefore be derived in a more general manner than is here shown. Macneil employed the prismoidal formula for computing his Earthwork Tables, (1833.) It was prominently brought to the notice of American engineers by Ellwood Morris, C. E., in this *Journal*, Vol. XXV., 2d series, pp. 25, 387; and Vol. XXIII., 3d series, p. 240. It was further discussed in the same *Journal*, by Prof. Gillespie, Vol. XXXIV., 3d series, p. 372, and Vol. XXXVII., p. 11, who, as far as I know, first directed the attention of engineers to the fact that this formula applies to solids contained under a warped surface; and Mr. Chauncey Wright has contributed a mathematical dissertation upon the extension of the formula.—*Mathematical Monthly*, Vol. I., No. 1, p. 21; and No. 2, p. 53. For some further historical notices, see the writer's New Theorems for the Computation of Earthwork, p. 10: H. C. Baird, Philadelphia.

1st end area $GBD + GCE = \frac{BH \times GD + CQ \times GE}{2} = \frac{(BH + CQ) \times GD}{2}$

$$= \frac{(S'_h + D'_h)(S'_b + D'_b)}{8} \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

Mid area $GBD + GCE = \frac{(BH + CQ) \times GD}{2} = \frac{S'_h S'_b}{8}$. (3.)

2d end area $GBD + GCE = \frac{(BH + CQ) \times GD}{2} = \frac{(S'_h - D'_h)(S'_b - D'_b)}{8}$ (4.)

Performing the multiplications indicated and then applying formula (1), there results after reduction—

Solidity $GBD + GCE = L \frac{S'_h S'_b + \frac{1}{3} D'_h D'_b}{8}$, . . . (5.)

If we suppose either pair of end triangles GBD or GCE to vanish, and consequently the solid contained between them, the form of this last equation will not be changed; but the factors $S'_h S'_b$, $D'_h D'_b$, will then represent the sums and differences of the side heights and bases belonging to the remaining pair of end triangles and their contained solid. If the end triangles are dissimilar, the solid will have one or more warped surfaces. If the end triangles are similar and unequal, the solid is a truncated pyramid; if similar and equal, the solid is a prism; if one of the end triangles vanish, the solid is a pyramid. For the prism, D_b' and D'_h vanish, and we have—

Solidity of prism $= L \frac{S'_h S'_b}{8}$, ... (6)

For the pyramid the sum and difference of side heights are each equal to the remaining side height, and the same relation exists for the bases. If we suppose GBD to be the remaining end triangle, we shall have by formula (5)—

Solidity of pyramid $= L \frac{BH \times GD + \frac{1}{3} BH \times GD}{8} = \frac{L}{3} \frac{BH \times GD}{2}$ (7.)

which represents the area of the base GBD, multiplied by one-third of the number expressing the length, and is the usual rule for the solidity of a pyramid.

The solid which has the united triangles GFB, GFC for a cross-section, is computed by a method precisely similar to that employed to derive equation (5), and produces a result entirely analogous. These triangles have the common base GF, with the altitudes respectively, OB and KC. We shall find—

1st end area $GBFC = \frac{GF \times HQ}{2} = \frac{(S_h + D_b)(S_b + D_h)}{8}$, . (8.)

Mid area $GBFC = \frac{GF \times HQ}{2} = \frac{S_h S_b}{8}$ . . . (9.)

2d end area $GBFC = \frac{GF \times HQ}{2} = \frac{(S_h - D_b)(S_h - D_b)}{8}$, . (10.)

And from these last three equations we find, by applying equation 1, as before,—

$$\text{Solidity } \text{G B F C} = \text{L} \frac{S_h S_b + \frac{1}{3} D_h D_b}{8}, \quad . \quad . \quad . \quad . \quad . \quad (11.)$$

The solidity of the work is found by adding together the solidities expressed by equations (5) and (11), which gives—

$$V_w = L \frac{S_h S_b + S'_h S'_b + \frac{1}{3} D_h D_b + \frac{1}{3} D'_h D'_b}{8} \quad . \quad . \quad . \quad (12.)$$

If the width of road-bed is uniform, $S'_b = B$ and D'_b vanishes; equation (12) becomes for this the usual case—

$$V_w = L \frac{S_h S_b + S'_h S'_b + \frac{1}{3} D_h D_b}{8} = L \frac{S_h S_b + S'_h B + \frac{1}{3} D_h D_b}{8}, \quad (13.)$$

If the solidity of the whole ground between the surface and the intersection of the side slopes be sought, it will be found by formula (11), for in that case we may suppose the road-bed D E to vanish, the point G to fall upon A, and the figure G B F C to become the whole cross-section A B F C. Instead of the centre height G F, we must employ the augmented centre height A F; that is, we must put in formula (11) S_H for S_h, D_H for D_h, and shall find—

$$V_s = L \frac{S_H S_b + \frac{1}{3} D_H D_b}{8}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14.)^*$$

If the height G F be not measured in the centre of the road-bed, the solidity may be found by computing separately and then adding the component solids. In the case where the height G F is measured out of the centre, as at G′, but at the same distance and on opposite sides of the centre at the ends, make $G G' = \frac{1}{2} d$. We shall have—

Sum of bases left $= (D G + \frac{1}{2} d) + (D G - \frac{1}{2} d) = S'_b$.

Difference of bases left $= D'_b + d$.

Sum of bases right $= (G E - \frac{1}{2} d) + (G E + \frac{1}{2} d) = S'_b$.

Difference of bases right $= D'_b - d$.

The solidity of the central solid upon G B F C is not altered by the change of the line G F to G′, provided the values of G F and H Q remain unchanged. For the side solids, we shall have according to the method of equation (5), supposing G′ to be joined with B and C,

$$\text{Solidity } G' B D = L \frac{S''_h S'_b + \frac{1}{3} D''_h (D'_b + d)}{8}, \quad . \quad . \quad . \quad (15.)$$

$$\text{Solidity } G' C E = L \frac{S'''_h S'_b + \frac{1}{3} D'''_h (D'_b - d)}{8}, \quad . \quad . \quad (16.)$$

* For another demonstration, see *New Theorems*, p. 283. The writer's first circulation in print of formulæ (14, 21 and 22) was made, without demonstration and explanation, in a pamphlet published in 1859.

These two united make—

$$\text{Solidity } G'BD + G'CE = L\frac{(S''_h + S'''_h)\,S'_b + \frac{1}{3}(D''_h + D'''_h)\,D'_b}{8}$$

$$+ \tfrac{1}{3}\frac{(D''_h - D'''_h)\,d}{8}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17.)$$

$$= L\frac{S'_h S'_b + \frac{1}{3} D'_h D'_b + \frac{1}{3}(D''_h - D'''_h)\,d}{8} \quad . \quad . \quad (18.)$$

Adding this solidity to that of equation (11), we have—

$$V_w = L\frac{S_h S_b + S'_h S'_b + \frac{1}{3} D_h D_b + \frac{1}{3} D'_h D'_b + \frac{1}{3}(D''_h - D'''_h)\,d}{8} \quad (19.)$$

In order to compute the volume V of a solid having everywhere a traperoidal cross-section, with a single warped ground surface, as the solid upon B C Q H, we proceed exactly as in deriving formula (5), and shall find a result entirely analogous. We have for every cross-section—

$$\text{Area } BCQH = \frac{(BH + CQ) \times HQ}{2},$$

an expression entirely similar to equations (2), (3) and (4), and requiring, in the formula for the solidity, only the substitution in equation (5) of the sum and difference of the bases H Q instead of those of the bases G D; we have therefore—

$$V = L\frac{S'_h S_b + \frac{1}{3} D'_h D_b}{8} \quad . \quad . \quad . \quad . \quad . \quad (20.)$$

Equation (14) may be transformed by putting $H' + H''$ for S_a, $H' - H''$ for D_a, $\beta' + \beta''$ for S_b, $\beta' - \beta''$ for D_b, we thus find—

$$V_s = L\frac{(2H' + H'')\,\beta' + (2H'' + H')\,\beta''}{12}, \quad . \quad . \quad (21.)$$

$$V_s = L\frac{(2\beta' + \beta'')\,H' + (2\beta'' + \beta')\,H''}{12}, \quad . \quad . \quad (22.)$$

The following geometrical considerations apply to the preceding investigations. We have found the area of a triangular cross-section, as G B D, equal to half the rectangle of the base G D and side height B H. The lengths of these lines, on any intermediate cross-section, depend on their initial and terminal lengths, and on the distance between the initial and intermediate cross-section, to which the increase or diminution of base or height is proportional. Hence the area G B D is everywhere independent of the distance out G H, and therefore the volume of the solid generated by the motion of G B D is the same, whatever be the relation between the initial and terminal lengths of G H; but this relation may be such that a warped surface is generated by D B or G H, or both.

(To be continued.)

Mechanics, Physics, and Chemistry.

APPARATUS ILLUSTRATING MECHANICAL PRINCIPLES.

By R. H. Thurston, U.S.N. Engineers, A.A., Prof. Nat. Philos., U. S. Nav. Acad.

Educators seem to have paid comparatively little attention to the illustration of the principles of mechanics by means of specially designed instruments. The catalogues of makers of philosophical apparatus are well filled in the several departments of physics, but display little of value beside the Atwood machine in this department, where the mind of the average student requires most assistance in the effort to seize and retain the, to him, difficult conceptions of the relations of static and dynamic forces.

At the Naval Academy, where, as in other technical schools, a knowledge of the science of mechanics is of the greatest importance to the student, this want has been seriously felt, and Assistant Engineer J. Pemberton, U. S. N., while acting as lecturer on that subject, during the past year, has designed and constructed a considerable number of new and particularly needed pieces of apparatus.

Of these, we select several of the most important for description. The illustrations exhibit them as ordered for the U. S. Naval Academy, and as about to be built by Messrs. Hawkins & Wale,* at the "Stevens Institute of Technology," under the direction of the designer.

The "parallelogram forces" has usually been found a *pons asinorum* to the beginner, and the "parallelopipedon" has been a stumbling block, not so much in the difficulties of its demonstration as in the conception of the relations between the forces themselves and among their geometrical representatives.

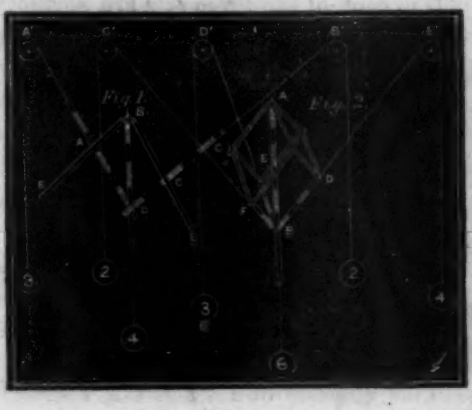
Several attempts have been made to illustrate these problems by means of apparatus, but none have been fully satisfactory.

The Pemberton apparatus as is shown in Figs. 1 and 2.

In Fig. 1 is illustrated the parallelogram of forces. The forces are measured off on the rods A D, B D, C D, respectively, the rods

* Instrument makers to the Institute.

being pinned together at D, and taking the directions of forces acting along the cords carrying the weights 3, 4, 2, as represented, two of them passing over pulleys at A′ and B′, while the third is attached to the lower end of the rod B D. In the special case shown, these weights are 3, 2 and 4. The apparatus now swings into a position of equilibrium, B D becoming vertical.



Laying off upon B D four units of length, it will represent the force 4, and therefore the resultant of the forces 2 and 3, in the directions D C and D A. On the rods D C and D A are equidistant holes, spacing off units of length equal to those on B D. In these may be placed pins to support the lower ends of the light rods B E and B F, which complete the parallelogram, when the pins mark off distances proportional to the component forces.

If, now, either of the weights be changed in magnitude, the figure becomes distorted, and can only be rendered again symmetrical by making corresponding changes in the length of the sides representing the altered forces. The rod B D is telescopic, to allow of such changes.

In Fig. 2 we represent the parallelopipedon of forces in a similar manner.

In this example B F is 2 units in length, B E 3 units, B A 6 units and telescopic, B D 4 units and also telescopic, and all concur at B.

When in equilibrium, the piece B A is vertical, and its length, 6, represents the weight, 6, which is the resultant of the three forces, B F, B E, and B D.

If the principle enunciated be true, the weights being arranged as in the figure, and the weight of the apparatus being taken into consideration as a part of the weight, 6, B A must be the diagonal, and B F, B E, and B D the edges of a parallelopipedon.

To prove this to the student, the representatives of the remaining nine edges of the figure, in groups of three, are so fitted that they may be attached at E D F and A without disturbing the equilibrium,

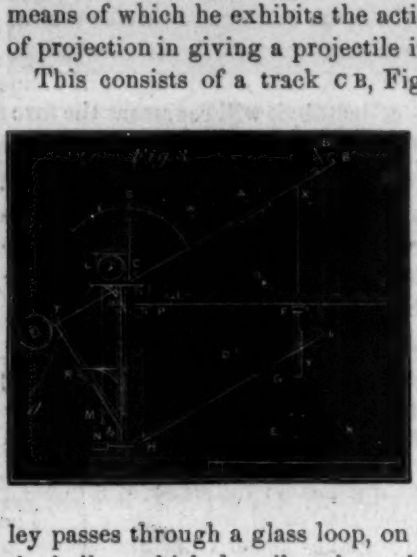
and the parallelopipedon is thus completed. The rods parallel to B D in each of the three sets are telescopic.

Here, again, any one weight being changed, the figure becomes distorted, and is only restored by the restoration of the proportionality between the lengths of the several sides and the magnitudes of the forces which they should severally represent.

With an apparatus in which the rods are made light, and the weights are comparatively heavy, the effect is most pleasing and satisfactory.

Passing by other equally useful and ingenious apparatus added by Mr. P. to our collection, we select, for illustration, a machine by means of which he exhibits the action of the forces of gravity and of projection in giving a projectile its parabolic trajectory.

This consists of a track C B, Fig. 3, movable on a hinge at C, which means of the elevating screw R T and the graduated arc S, can be set at any required "angle of elevation."



The track supports a carriage, A, which carries a pulley, so suspended as to turn very easily. Over this pulley passes a fine wire, or thread, carrying the weights D and E at its extremities. That portion of the cord hanging on the right hand side of the pulley passes through a glass loop, on the guide block G, and carries the ball O, which describes the path of the projectile.

Attached to the carriage are two cords: one passes over the pulley B, thence to a barrel on the clock-work L. This clock is driven by a spring, and runs with a uniform motion, but very much faster than an ordinary clock. The cord, just mentioned, after passing around the clock barrel by which it is driven, hangs downward and carries a weight, M.

The second cord passes from the carriage A over the pulley B′, and sustains a counterbalance weight, K. A third cord passes from W, on the cord L B, over the pulley B, thence to the pulley I and to the guide G, to which it is made fast.

The piece H I is kept parallel to the carriage track B′ C by means of the rod X Y.

The platform N is so connected with the clockwork, through the the rod, *b a*, and a set of levers, that, when the weight M strikes it, the clock will be stopped. The rod *b a* also exhibits a scale of equal parts.

The carriage track having been given any desired angle of elevation, the apparatus is operated as follows:

The carriage is placed at the bottom of its track, at which time the ball O is hidden in or behind the turret of the iron-clad P.

The weights D and E are first made equal, and the clock wound up.

The lanyard *d* being pulled, the clock starts, and carries the carriage up the track with a uniform motion.

Since D and E are equal weights, the ball O will move in a line parallel with C B′, thus exhibiting the trajectory of a projectile acted upon by the force of projection, but freed from that of gravity.

It thus presents the first component of the motion of the projectile under ordinary circumstances.

A small weight, representing the force of gravity, is now added to E, and the ball descends vertically from the elevation just attained, with an accelerated motion, exhibiting thus the second component of the motion of the projectile—that due to the action of gravity.

The carriage is again placed at the lower end of its track, the weight E remaining the greater. On starting the clock, the ball now describes the parabolic path under the action of both components, and falls into or behind the fort F, placed at a distance from P equal to the estimated range.

The motion is so slow that the eye has no difficulty in following it. The *range* is measured on the graduated water line P F. The hands of the clock being placed together at zero, and the weight M adjusted so that it shall reach the platform N when the projectile strikes the fort, we have the *time of flight* registered.

From the time of flight and the distance fallen through by M as measured at the scale *a b*, we may compute the initial velocity; by increasing or diminishing the weight K, we may exhibit the effect of varying the charge of gunpowder, and, in fact, *all* of the circumstances of the motion of a projectile in vacuum may be illustrated, and equations are verified with gratifying precision.

Space will not allow of the description of the apparatus for illustrating the rolling of ships, and the relation of their centers of buoyancy, and gravity, and the metacenter, or to refer to others of these novel, valuable and interesting additions to our mechanical apparatus, for which we are indebted to the peculiar talents of Assistant Engineer Pemberton.

Stevens Institute of Technology, Hoboken, N. J., June, 1871.

ON THE USE OF HYDRAULIC MORTAR.

[Translated from "Die hydraulischen Mörtel" of Dr. W. Michaëlis, for the Journal of the Franklin Institute.]

By ADOLPH OTT.

(Continued from page 144.)

SINCE Bélidor's time, all mortar mixed in the above mentioned manner is called beton. As will be seen at the first glance, it differs from common hydraulic mortar, inasmuch as gravel and larger fragments of rock are used along with or in place of finer sand. It is altogether indifferent whether these are at once added during the first mixing process, or whether they are subsequently incorporated with the mortar mass, as has been recommended by Bélidor with regard to the larger stones or pieces of rock. The only difference, therefore, which may have existed between beton and concrete, has been long since set aside in practice.

Pasley, according to whom the English first used concrete in 1817, (Penitentiary at Millbank—Robert Smirke) insists upon its difference from beton, inasmuch as it is mixed with smaller stone-fragments like gravel. But, as far as our investigations reach, it would be wrong to suppose that the difference between beton and concrete arises from the constant use of lime of an hydraulic nature, while no water-lime was at first used for concrete.

The great importance of beton masonry is based above all upon the fact that it enables us to construct a very solid foundation wall, as good as if it consisted of one solid piece, even where no quarry stone can be had, and capable of holding off all subsoil moisture or water; besides, it admits of the construction of foundations under water at a considerable depth without requiring the previous drainage of the building ground. All that is necessary is the erection of a coffer-dam to protect against the commotion of the water. Even this may be done away with in all cases where artificial stone blocks are used, as the foundation work can be safely constructed by immersing them during a calm, when there is no necessity of any outside protection against the sea, as has been done at the port of Cette.

Although beton was at first used for foundation work only, it has since been made available for construction above water with the greatest success. Indeed, wherever good hydraulic material

can be procured, unusually solid buildings can be rapidly constructed at comparatively little cost. From what we have been able to learn, a French architect, named Lebrun, at Alby, (Département du Tarn) has been the pioneer in this kind of construction, in building a dwelling house on his country seat in 1830, made altogether of beton. The house consisted of a basement with three vaulted rooms, a first story with three rooms, and a vaulted loft or garret.

Mr. Gourlier, in a report to the Société d'encouragement says, that the entire building, even the arcades, the mouldings which serve as decorations of the outer walls, the steps which lead outside from the basement up to the main story, as well as the vaults of the lower story, were all constructed of beton.

Of these vaults or arches, those of the three rooms of the basement have a width of $5^{m}{\cdot}3$, a height of 1^{m}, and a strength at the apex of $0^{m}{\cdot}25$. Of the two Roman arches which support the roof, the larger one has a width of $6^{m}{\cdot}2$, a strength of $0^{m}{\cdot}25$ at the abutment, and of $0^{m}1{\cdot}5$ at the crown. Each of the ceilings of the first story is divided into three parts by two beams which are $1^{m}{\cdot}8$ away from each other; the space between the beams is filled up by a small vault of the height of $0^{m}{\cdot}15$; strength, $0^{m}{\cdot}25$ at the abutment and $0^{m}{\cdot}10$ at the crown.

The beton consisted of:

1 part of hydraulic lime from Alby, slaked by immersion;
1 " clean sand: and
2 " rubble stones of the size of 8–10 centimeters.

The mortar was long and carefully mixed, and was then vigorously pressed down upon the wooden boxes, by means of which the structure was built up in blocks of the height of $0^{m}{\cdot}3$.

The arcades, arches and vaults were erected on centres, and the mouldings were made with the aid of patterns. The plastering consisted of a thin coat of mortar mixed with sifted sand, which, after being duly smoothed down, made the walls completely even, with polished surface and sharp edges.

During the summer season the mortar had to dry six hours, during the spring twelve hours, when it had sufficiently hardened, and the work could be continued. The centres were removed after from thirty to seventy-five days. The structure proved to be an excellent one, and of undoubted durability, while the cubic meter

of its masonry costs but a trifle more than three-eighths of the cost of brick walling.

We must here remark, that beton mortar has been used on the island of Santorin, since time immemorial, for the construction of cisterns, terraces, vaults, etc. It is said that the terraces which there form the roofing of the houses, are made of a beton substance consisting of:

6 parts of Santorin earth,
2 " paste of lime,
1 " sand, and
8 " fragments of bricks.

and that the following most simple proceeding is generally resorted to for the construction of vaults: A rough framework is built up and covered with shingles or boards; on these a layer of earth and rubbish is laid, and equalized after a pattern to correspond with the form of the vault to be built over it; then comes a layer of beton, composed of:

4 parts of Santorin earth,
1 " paste of line, and
8 " fragments of quarry stone.

After a lapse of twelve days the framework may be removed with safety.

Since that time the construction of buildings with beton has increased more and more, especially in Denmark and Sweden.

These buildings are erected without any serious difficulty; it is very easy to construct air holes and chimney flues, as well as double insulated walls. The material is such as affords the greatest security against danger from fire; it protects against all external moisture, and secures an almost constantly even temperature in the interior of the building. Whenever wood and building stones are scarce and dear, and where hydraulic materials can be had in abundance, it will be found greatly advantageous to make use of the latter to the fullest extent.

The various experiments made by the Danish Artillery Commission, during a period of ten years, warrant the belief that beton masonry is best adapted to fortification purposes, not only for such forts which are either surrounded by the sea, or situated on the coast, but also for those in the interior.

The splendid sea fortifications in front of the city of Copenhagen are exclusively built of beton masonry, as it was ascertained to be decidedly more bomb-proof than any other kind of masonry.

Beton masonry, while on the one hand of the same solidity with the best bound masonry known, has, moreover, the same peculiarity as loose substance, like earth, inasmuch as shot and shell produce an entirely limited local destruction; this, however, is the principal desideratum for a structure intended to be bomb-proof.

(To be continued.)

THE SUN.

A Course of Five Lectures, before the Peabody Institute of Baltimore.

By Dr. B. A. GOULD.

(Continued from page 133.)

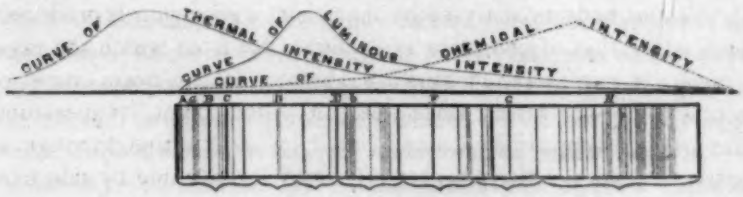
THEN the wonderful analysis of light, by the prism, reveals to us in each individual ray of pure white light, in every plane, a myriad of rays, of each intermediate wave length, from the longest to the shortest which the human eye can appreciate. The length of the waves which form any of these ultimate rays manifests itself to the prism by its refrangibility, and to the sense of sight by the impression of color. The longest of the visible waves are the least refrangible—appearing to the eye as red, and having a length of 155 ten-millionths of an inch; the shortest are the most refrangible, and produce the impression of violet—the extremest shown by a common glass prism having a wave length of about 271 ten-millionths of an inch, and all other colors are intermediate between these two. But there are other rays in sunlight more refrangible than the violet, and although our eyes do not usually recognize any of them, and never all of them, they are manifested to us by their chemical action. So, too, there are rays less refrangible than the farthest visible red, and these make themselves known to us as heat. In fact, the length of the solar spectrum producible by a prism is some 5½ times as great as that portion which is perceptible to the eye, by its rainbow tints, and it extends from rays whose undulations are 154 trillion to those in which there are 967 trillion undulations in a second. These various rays of different wave lengths may all be separated and individually examined by a proper com-

bination of prisms, and the apparatus for testing them optically is called a spectroscope. Scarcely ten years have elapsed since discoveries were made which have rendered this a marvelously delicate and potent implement of scientific investigation, with which neither the chemist, the physicist nor the astronomer can at present dispense, and which is rapidly finding important applications in various useful arts.

Thus equipped with the polariscope and the spectroscope, the astronomer finds unsuspected revelations in each ray of light which reaches him from a heavenly body, and these have within a few years largely increased our knowledge of the sun, and rendered our conceptions of his nature far more definite than before.

Few subjects are more fascinating than this of the spectral analysis of light, and it would be an agreeable duty to dwell upon it, and set forth the processes involved, and the gradual, though rapid and still active progress of discovery—to consider the various theoretical inferences suggested by the discoveries already made, and to describe the details of the investigation of sunlight. But this would imply a course of lectures upon this subject alone. I will leave all these points untouched, and simply tell of the results attained. It must therefore suffice to say that when the light from any celestial body is analysed by the prism, a spectrum is produced which is not that of complete white light, but from which the rays of certain special wave lengths are absent. If the beam come to the prism through a very small aperture like a point, its spectrum will of course appear as a line; but if it be admitted through a narrow slit, and a series of spectra thereby formed side by side, one for each point in that slit, it will present the appearance of a long band, of which the width represents the length of the slit, while its length depends upon the power of the prism in separating the rays of different wave-lengths in the original beam, and displaying them side by side. These rays, if concentrated by a lens, would reproduce the original beam; but if again passed through a prism, they become still farther analyzed and displayed. Now, it has long been known that such a spectrum, formed from sunlight, is crossed by a large number of dark lines, each of them corresponding, of course, to a row of dark points—one in the spectrum of each of the several points of light transmitted by the slit; or, in other words, corresponding to a ray of some particular degree of refrangibility which is wanting. The light of the moon and of the brighter planets is

polarized to a considerable extent, but shows the same dark lines as sunlight; thus furnishing independent proof, were any needed, that what we receive from them is reflected sunlight. The light from fixed stars, on the contrary, is unpolarized, and differs from sunlight in its spectral lines; and indeed each star appears to have its own characteristic series of lines, differing more or less from those of any other star. The explanation of these lines is now known, through the brilliant discoveries of Stewart, Angström, and Kirchhoff, who have found that each chemical element, when incandescent at a given temperature, gives off rays of particular wave-lengths, and that these same elements, in the form of vapor, will abstract from transmitted light those very rays which, as incandescent solids, they would omit. Thus the presence of dark lines in a spectrum indicates that the light has traversed some medium which has absorbed the missing rays; and the presence of rays of any particular refrangibility gives token of the nature or temperature of the luminous body whence they emanate. In general, a few bright lines imply a gaseous origin for the light, and point to that particular gas or vapor which would absorb those rays from white light traversing it.



More than this I may not stop to recount concerning the means of inquiry; but these few words may perhaps show to those unacquainted with the nature of spectral analysis, the degree of confidence fairly attributable to its results.

As long ago as 1811, the eminent French philosopher, Arago, tested the different parts of the sun's disk by the polariscope; and from the absence of any polarization in the light from the limb itself (notwithstanding it must come to us from an angle of very great obliquity), he inferred* that the source of sunlight was neither liquid nor solid, but purely gaseous. Subsequent discovery has somewhat modified this conclusion, while confirming its basis—as

* *Mem. Acad. Paris*, 1811, Pt. I, p. 118; *Kosmos*, III, 395, 418.

will hereafter be seen. And Forbes, in 1836 (before the spectroscope, as we now know it, was dreamed of,) availed himself of an annular eclipse of the sun, when only the margin of his disk was visible, to examine the spectrum then formed. He found* its lines the same in all respects as when the central portions of the disk were visible, and thus discovered that it is only in intensity, and not in quality, that the marginal light differs from that at the centre.

Up to the present time, more than 3500 lines have been recognized in the sun's light, and their positions in the spectrum determined. Of these, a considerable portion, perhaps 600 or 700 in all, is due to the absorptive action of our own atmosphere; another portion, numbering above 800, represents the lines of the 16 metallic elements which I have already mentioned as existing at the sun; the remainder are as yet unexplained. And if we have recourse to other implements of analysis, and examine the heat-rays beyond the red, and the photolytic rays beyond the violet, we find in the lines thus discoverable new fields of research, as yet but slightly explored.

You will not fail to remark that these dark lines signify that the light has passed through a gaseous medium, outside the photosphere, or luminous surface. The existence of such an atmosphere was previously indicated by the comparative dimness of the limb, and it was an essential part of the early theories which required so many envelopes, inasmuch as these envelopes themselves must need support. So, too, if the faculæ are elevations above the general level of the surface, as now seems beyond reasonable doubt, they too imply a supporting atmosphere. But no definite evidence of that refraction which an atmosphere must exert has yet been obtained, so that its density outside the photosphere cannot be very great. Small irregularities detected in the apparent motion of the spots, originally attributed to the effect of refraction, have recently been proved by Faye† to be due to the parallax occasioned by the depth of the cavity; and when the margins, and not the nuclei, of the spots are taken as the points of observation, these inequalities disappear.

* *Comptes Rendus*, II, 576.

† *Comptes Rendus*, LXII, 708; LXIII, 196.

PAPERS FOR THE USE OF STUDENTS.

No. 1.—On the Measurement of the Angles of Crystals.

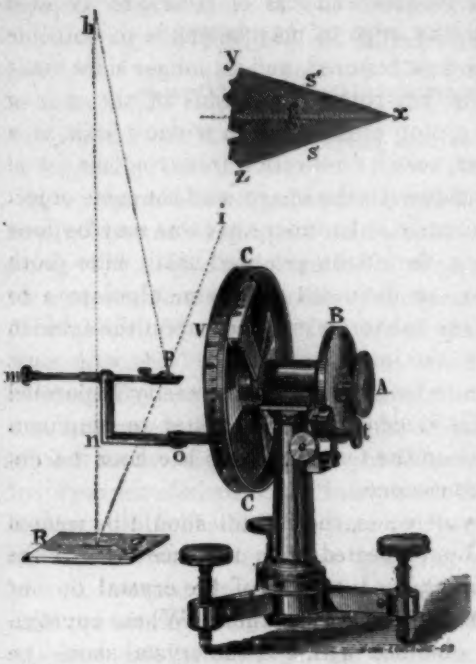
By Prof. LEEDS.

IT will be necessary in this and following articles to give a minute description of the apparatus which we propose to employ, and of the proper method of using it. But our chief object is to point out the difficulties which the student will encounter, the errors to which his measurements are liable, and the way of dealing with both.

With regard to the common goniometer, however, but little need be said. If it is graduated to whole or half degrees, an approximation nearer than fifteen minutes to the true angle cannot be demanded. When the faces of the crystal which include the required angle are very rough, or small, or partially imbedded, the permissable error is greater. In a properly constructed instrument, when the arms are pushed backwards and forwards, the central line of the slots constantly coincides with the axis. Moreover, the bevelled edge of the arm which is used for reading is coincident with the extension of the central line of the slot. In some common goniometers of superior workmanship, through ignorance on the part of the maker, the brass piece through which the axial screw is passed, is swelled into a disk at the end, and prevents the measurement of obtuse angles, and also of acute angles of small crystals. It must be ground away until the brass surface falls a little within the outer surfaces of the arms.

Wollaston's Reflective Goniometer.—In case the faces of a crystal are bright enough to reflect an image distinctly, the angles included between them may be measured by a greatly superior instrument, the reflective goniometer of Wollaston. Even with very small crystals, the determinations should be accurate almost to the minute. It consists of a vertical circle C C, graduated to half degrees. The vernier V, with its scale of 30 divisions, permits the reading of the half degrees to be carried to minutes. The wheel B should be secured immovably to the axle of the circle C C, and should communicate its motion backward and forward, without loss or change to the graduated circle, to the parts *o n m*, and to the crystal to be

measured. A final adjustment is made by means of the tangent screw, *t*. The wheel A communicates directly with *m n o* by means of a rod which passes through the hollow axle of B and C, and rotates the crystal without disturbing the graduated circle. The crystal is attached by wax to the plate *p*, which can be moved from side to side, or secured by a screw that passes through one side of a slit made in the end of the sliding rod *m*. By means of the parts *o n m p*, the crystal may be placed in any required position. In the first place, by altering the position of *p* in the slit, or by revolving it around the end of the screw as a centre point; by rotating *m* upon itself, or sliding it in and out; by revolving *n o* around the hinge *o*.



The adjustment of a crystal *y x z*, consists in making the edge *x* between the faces whose angle is to be determined parallel with the axis of the graduated circle, and in making this axis fall somewhere in the plane *f x*, which bisects the required angle. The measurement of the angle of a crystal consists in finding precisely the direction of any normal, as F S, drawn to one of the faces, and in noting through how many degrees and minutes the corresponding normal *f s*, drawn to the other face, must be revolved in order that it should take up the same position as that formerly occupied by *f s*. Such an adjustment is best effected in the following manner and order: The part *n o* is made perpendicular to the graduated circle.

The sliding rod *m* is pushed in or out until a line drawn through *o* parallel to the circle C passes through the middle of the plate *p*. The plate is then detached and the crystal adjusted by the eye, so as to fulfil as nearly as possible the conditions mentioned above.

This is a troublesome operation, but by using great care in its performance much subsequent trouble and loss of time are avoided If the crystal is very small, the edge x may be made to coincide with the axis. The plate is now restored, and its longer sides made parallel with the axis. It is then rotated by means of the sliding rod until the image of the top or cross-bar of a window sash, at a distance of from 6 to 12 feet, seen by reflection from the face $y\,x$ of the crystal, is made to coincide with the image G of the same object seen by reflection in the mirror R. In order that this may be done conveniently, the instrument should be elevated until, when both elbows rest upon the table, one hand may easily manipulate A or B, and the other m or p. The mirror R is placed upon the table in such a position as to allow the image of h to be seen with ease. Since the image reflected in the mirror must of necessity be parallel with the cross-bar itself, it is evident that it is better to employ a mirror than to rule a line upon the table, or upon the floor in front of the window, as is sometimes done.

If the two images nearly coincide, the crystal should be rotated by m, and the same operation repeated with the face $z\,x$. If the coincidence is far from perfect, the position of the crystal on the plate is to be altered before proceeding further. When approximate coincidence has been obtained with $z\,x$, the crystal should be rotated backwards, to see that in this operation the approximate coincidence, so far as the first face is concerned, has not been destroyed. When this part of the work is carefully and thoughtfully performed, the final adjustment may be easily effected. This consists in rotating the crystal by the wheel A, and in perfecting the coincidence of the images, as seen in both faces by slight movements to and fro of the part $o\,n$ and the plate p.

The measurement of the angle is a much easier operation than the adjustment. It is effected by bringing one eye as near as possible to the crystal (it is better to keep both eyes open), and maintaining it in precisely the same position. The discrepancy between successive measurements of the same angle is largely due to slight inadvertent changes in the position of the eye of the observer. Down to a certain limit, the error from this cause is less, as the faces including the angle to be measured are smaller. The position of $n\,o$ should be so adjusted in the beginning, that when the crystal is rotated it should not come into the way, and bring about a change in the place of the observer's eye. The wheel A is then rotated until

coincidence of the images is obtained in one of the faces. If there is any difficulty in procuring such a coincidence by the motion of A alone, the wheel B should be clamped, and the tangent brought into use. The number of degrees and minutes is now to be noted by examination of the graduated circle and vernier, with the aid of a magnifying glass. The crystal is then rotated by B, care being taken to impart no motion to A during the operation, until exact coincidence is established in reference to the second face. The difference of the readings subtracted from 180° gives the angle required. This is true of such an instrument as is figured above, the circle of which is graduated to 360°, and can be rotated in two directions. In some instruments, however, the circle is graduated from 0° up to 180°, and this 180° again is made the zero point of another graduation into 180 divisions, ending with the point of beginning. And furthermore, the circle is provided with a stop, which arrests the motion when the point marked 180° coincides with the zero of the vernier, and makes it necessary to rotate the circle from 180° towards the zero point of the circle. Consequently, the reading obtained, when the position of the second face of the angle of a crystal is properly adjusted, is the angle required.

In using Wollaston's goniometer, the following precautions should be taken: 1st. The axis of the instrument should be horizontal. 2d. The plane of the graduated circle should be perpendicular to both lines. Both these points can be determined with sufficient nicety by inspection. 3d. The graduated circle should be centred with the greatest accuracy. This should be tested by performing the measurement of the same angle with every successive portion of the circle. A hexagonal crystal, such as quartz, will be found convenient in such a determination. If the circle is not accurately centred, the angles found will be too large on the side of the circle where the radii are smaller than the half diameter, and too small when they are greater. 4th. The motion of A and B should be altogether independent. 5th. The clamping and unclamping of the tangent-screw should make no difference of position of the circle. 6th. The wheel B and the circle C should be maintained at a constant tension (in Soleil's instruments this is effected by a circular spring washer of brass, placed between B and the central part surrounding the axle), so as to remain stationary while B is rotated, while at the same time there should be no "wabbling" of B upon the axle of C. For the sake of illustration, I append this series of

measurements of one and the same angle, taken before this source of error was suspected:

360° 38′	300° 19′	240° 43′	180° 53′	121° 8′	60° 49′
300° 52′	240° 35′	180° 52′	120° 52′	60° 51′	56′
59° 46′	59° 44′	59° 51′	60° 1′	60° 17	59 53′

The true angle was 60°.

This source of error may be exposed at once by tightly clamping the tangent-screw, and observing, by means of the vernier, whether there is any change of place of the graduated circle when strongly twisted to the right or left. If it moves, the wheel B is forced up upon the axle until it is perfectly secure, the circular spring washer being made thinner if necessary.

I give below some determinations of the angles of a small crystal of quartz from Lake George, in order to illustrate the method of working by an easy example. In four measurements, we obtain for the supplement of the angle included between two faces of the prism, 59° 59½′. This may be seen by taking the mean of the following results:

360° 9′	300° 5′	240° 5′	180° 6′
300° 5′	240° 5′	180° 6′	120° 10′
60° 4′	60°	59° 59′	59° 56′

In this particular crystal, it happens that the face 2–2 is so small that it is only by the beam of light which it reflects into the eye when rotated to the proper position, that the attention is attracted to its existence; yet this beam is sufficiently distinct to subserve our purposes in measurement. Since the face of the rhombohedron immediately adjoining 2–2 is likewise very small, we may measure all the angles lying in one zone at the same time. This is done by seeing that the two images can be made to coincide when the four including faces are brought successively into view. The results thus obtained are as follows:

For $i \wedge 22$,

246° 32′	133° 26′
205° 22′	95° 11′
38° 10′	38° 15′

Supplement of mean,	147° 48½′.	
For 22 ∧ R,	208° 22′	95° 11′
	179° 18′	66° 10′
	29° 4′	29° 1′
Supplement of mean,	150° 57½′.	
For R ∧ −1,	150° 57½′	
	292° 32′	179° 15′
	246° 13′	133° 3′
	46° 19′	46° 12′
Supplement of mean,	133° 44½′.	

NOTE.—It may appear strange to the student that the angle formed by the ray reflected from the face of the crystal, should be assumed equal to that reflected from the mirror. It is evidently greater when both surfaces are horizontal, and consequently parallel. In fact, to effect coincidence of the two reflected rays, the crystal must be rotated until the face under observation dips slighty downwards in the direction of the window. But the second face of an angle must be made to dip by precisely the same amount, and the difference of the two readings gives exactly the angle required.

THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

BY PROF. HENRY MORTON, PH.D., President of Stevens Institute of Technology.

Continued from Vol. LV. page 420.

DURING the time which has elapsed since the publication of the last paper in the series on the above subject, which appeared in this *Journal* in the 53d, 54th and 55th volumes, many new points of experience and observation have come within my field of view, which are of value in connection with the same subject, and with which I propose to supplement my former papers.

In the first place, with reference to the preparation of oxygen, many methods for which are noticed in the article Vol. LIII. page 55 of this *Journal*.

Preparation of Oxygen.—An experience of several years has led me to the exclusive use of the apparatus to be now described as preferable to any of the others before mentioned.

A conical vessel is obtained, which any tinman can make of thin

sheet-iron, such as is used for stovepipes. It is 11 inches high, 6½ inches in diameter at the bottom, and 1¼ inches at the neck. The joints are "upset" and hammered close, which makes them nearly air-tight. A piece of light brass tubing, large enough to fit over the conical neck, is then closed at one end and provided with a lateral branch of, say, ¼ inch diameter and 5 inches length.

The charge of, say, one pound chlorate of potash with 4 to 6 ounces of black oxide of manganese is put into the iron vessel, and the top luted on with a little plaster of Paris, and the first time the vessel is used some very thin plaster is run into the seams. A wash bottle is then connected with the outlet tube by rubber hose, and the gas bag with the wash bottle. Fig. 1 shows the whole apparatus, including the gas stove, ready for use.

Fig 1

A good heat is applied to the bottom of the iron vessel, and continued until the gas comes through the water in the bottle with considerable rapidity, when the heat may be diminished, but should be renewed at once if the flow of gas decreased.

The theory of a safe and successful working of this process is this: If the mixture is very rapidly heated, one part of it will be entirely decomposed without fusing before another part has reached the required temperature, and so the evolution of gas will be gradual and steady. But if the heat is more gradually applied, the entire mass may be slowly fused with very slight escape of gas, but when once the temperature for this is reached the action goes on simultaneously throughout the mass, and is so of a very violent character. There is then, also, a liability for the melted material to froth up and close the outlet. The only risk in connection with such an accident, if these sheet-iron vessels are used, is that of making a dirt, for the flat bottom of the retort yields to a very moderate pressure, and opens at the edge with a puff, which can hardly be called an explosion.

By applying the heat rapidly, as with a good gas-stove or coal-fire, all difficulty can, however, be entirely avoided. The heating cannot be too rapid, the only trouble is from a want of heat at first. I have blown the bottoms out of several retorts in experimenting

on this subject, and now feel perfectly secure of a satisfactory result where a sufficiently strong heat is at command.

The wash bottle should never be omitted; it indicates the progress of the reaction and prevents such accidents, from distillation of the rubber tubing or bag, as are described in this *Journal*, Vol. LV., pages 4 and 81,—and which are sometimes of a very serious character.

After using, the retort above described should be cleaned out by breaking up the residuum with a sharp stick, and not by washing. The retorts will then last for a very long time, indeed, far outlasting those made of copper.

Gas Bags.—The oxygen gas bag should be distinguished from that used for illuminating gas by a marked difference in its stopcock. A mark on the bag is well also, but likely to be useless when most needed, namely, in the dark, as when in use. By using hydrant cocks for the one gas, and gas cocks for the other, all chance of mistake, even in the dark, can be obviated.

Condensers.—The attempt has frequently been made to employ very large condensers for small pictures by setting the latter forward in the cone of rays coming from the former until the picture was just covered by the contracting field of illumination, and thus getting all the transmitted light upon the picture. The object glass used in such a case would of course be of a shorter focus than that employed with a large picture set close to the condenser, or if not, would be moved proportionally forward.

Such an arrangement is, however, in all cases more or less unsatisfactory, giving a field of light on the screen, which is apt to be defaced by a blue-grey ring near the centre and with a red edge, and though by special adjustment and the covering of the margin with a diaphragm, a tolerable result may be obtained, this is never equal to that which the same light will yield with condensers well proportioned to the pictures to be used. As the cause of this has not to my knowledge been anywhere discussed, and leads moreover to some very important general principles bearing on the structure of condensers, I think that a brief explanation will not be amiss in this place.

If a system of condensers are well arranged, the front surface of the outside lens will be evenly illuminated, as may be seen by placing a sheet of thin paper against it, but from this surface the rays will travel outwards with all the irregularities of distribution

caused by spherical and chromatic aberration, and by the action of the condensers as image-producer of the source of light.

If now the object-glass, while in focus with the object, is also in focus with the front of the condenser, it will produce on the screen an image of the equally illuminated surface of the condenser, the irregularities in direction of the rays as they leave that surface having, as we know from the simple theory of image formation by lenses, no effect inimical to such a result. But if the object is moved forward on the cone of rays issuing from the condenser, then, when the object glass is in focus with this, it will tend to produce an image of a section of the light-cone made in this same plane. Here, however, the irregularities in distribution of the light before noticed have developed to the extent of rendering the area of such a cross section very irregular in illumination and

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SOME REMARKS ON "EXPERIMENTAL INVESTIGATIONS OF A NEW FORCE, BY WILLIAM CROOKES, F. R. S."

By Coleman Sellers.

In the paper under the above quoted caption, which was given to the world in the July number for this year of the London *Quarterly Journal of Science*, there is a foot note, p. 341, as follows: "It argues ill for the boasted freedom of opinion among scientific men, that they have so long refused to institute a scientific investigation into the existence and nature of facts asserted by so many competent and credible witnesses, and which they are freely invited to examine when and where they please." The experiments which Mr. Crookes describes in the paper, and which he is not afraid to give to the world as convincing proof of the existence of a force, to which he has ventured "to give the name of Psychic," are in all respects similar to those shown in this country by so-called "medi-

on this subject, and now feel perfectly secure of a satisfactory result where a sufficiently strong heat is at command.

The wash bottle should never be omitted; it indicates the progress of the reaction and prevents such accidents, from distillation of the rubber tubing or bag, as are described in this *Journal*, Vol. LV., pages 4 and 81,—and which are sometimes of a very serious character.

After using, the retort above described should be cleaned out by breaking up the residuum with a sharp stick, and not by washing. The retorts will then last for a very long time, indeed, far outlasting those made of copper.

Gas Bags.—The oxygen gas bag should be distinguished from that used for illuminating gas by a marked difference in its stopcock. A mark [illegible] also, but likely to be useless when most needed, r
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In title, for *Investigations* read *Investigation.*

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employed with a large picture set close to the condenser, or if not, would be moved proportionally forward.

Such an arrangement is, however, in all cases more or less unsatisfactory, giving a field of light on the screen, which is apt to be defaced by a blue-grey ring near the centre and with a red edge, and though by special adjustment and the covering of the margin with a diaphragm, a tolerable result may be obtained, this is never equal to that which the same light will yield with condensers well proportioned to the pictures to be used. As the cause of this has not to my knowledge been anywhere discussed, and leads moreover to some very important general principles bearing on the structure of condensers, I think that a brief explanation will not be amiss in this place.

If a system of condensers are well arranged, the front surface of the outside lens will be evenly illuminated, as may be seen by placing a sheet of thin paper against it, but from this surface the rays will travel outwards with all the irregularities of distribution

caused by spherical and chromatic aberration, and by the action of the condensers as image-producer of the source of light.

If now the object-glass, while in focus with the object, is also in focus with the front of the condenser, it will produce on the screen an image of the equally illuminated surface of the condenser, the irregularities in direction of the rays as they leave that surface having, as we know from the simple theory of image formation by lenses, no effect inimical to such a result. But if the object is moved forward on the cone of rays issuing from the condenser, then, when the object glass is in focus with this, it will tend to produce an image of a section of the light-cone made in this same plane. Here, however, the irregularities in distribution of the light before noticed have developed to the extent of rendering the area of such a cross section very irregular in illumination and color, and this irregularly illuminated surface the object glass will reproduce in the image which it throws upon the screen.

One general conclusion to which this view of the subject leads us is, that in arranging a set of lenses to form a lantern condenser, we must have in view the equal illumination of the outer surface as one of the vital elements.

(To be Continued.)

SOME REMARKS ON "EXPERIMENTAL INVESTIGATIONS OF A NEW FORCE, BY WILLIAM CROOKES, F. R. S."

By Coleman Sellers.

In the paper under the above quoted caption, which was given to the world in the July number for this year of the London *Quarterly Journal of Science*, there is a foot note, p. 341, as follows: "It argues ill for the boasted freedom of opinion among scientific men, that they have so long refused to institute a scientific investigation into the existence and nature of facts asserted by so many competent and credible witnesses, and which they are freely invited to examine when and where they please." The experiments which Mr. Crookes describes in the paper, and which he is not afraid to give to the world as convincing proof of the existence of a force, to which he has ventured "to give the name of Psychic," are in all respects similar to those shown in this country by so-called "medi-

ums," and which have been cited as convincing proof of the presence of "spirits," to act through certain persons upon inanimate matter. So far from scientific men being unwilling to examine into these "facts," I have never met any but who were rather anxious to have an opportunity to make such tests as they deem proper to avoid the possibility of trickery. Time and again has deception in these practices of "mediums" been discovered, and time and again have they been exposed; yet, with what result? "Believers are believers still," as Prof. Tyndall in his Fragment of Science, says, when speaking of his attempts at an investigation. "It is in vain that impostors are exposed and the special demon cast out. He has but slightly to change his shape, return to his house, and find it empty, swept and garnished."

In regard to the "timidity or apathy shown by scientific men in reference to this subject," it may be said, scientific men are men who make the natural sciences a study, and some are more competent to investigate certain subjects than others are. Those best fitted, from education and practice, to consider any one scientific subject, are usually termed experts in that particular art or science. Now, the question at once arises as to what class of experts such phenomena as those described by Mr. Crookes should be referred. Among numerous scientific men of note with whom it has been my good fortune to be intimate, I have found none who were experts at legerdemain. They had turned their attention to matters of more account, and yet were always interested when looking at skillfully conducted deceptions. Experts in sleight-of-hand prefer showing their skill to educated people, as they can the more readily appreciate the perfection of the deception, and yet are no more likely to detect the artifice than others. Among mechanics can be found many who have turned their attention, by way of pastime, to these mechanical puzzles, and to them it affords a healthy mental exercise, to devise ingenious combinations, and to work them out with the supple fingers of the skilled workman. A mechanic, reading of the experiments as described by Mr. Crookes, does not see in them any proof of the existence of any new force, but sees only the possibility of deception by very simple means. But mechanics are not usually classed among scientific men; and perhaps their testimony would be ruled out of the grand court of inquiry.

On page 341, again, we have given a mahogany board, "36 inches long by 9½ inches wide, and 1 inch thick," with "at each end a strip

of mahogany, 1½ inches wide, screwed on, forming feet." This board was so placed as to rest with one end on the table, the other suspended by a spring balance, and, so suspended, it recorded a weight of 3 pounds; *i. e.*: a *mahogany* board of the above dimensions is shown to weigh 6 pounds—3 pounds on the balance and 3 pounds on the table. A mechanic used to handling wood wonders how this may be. He looks through his limited library, and finds that scientific men tell him that such a board should weigh about 13½ pounds. Did Mr. Crookes make this board himself? or did Mr. Home (whom the papers here call "the great American Spiritualist") furnish it as one of his pieces of apparatus? A similar machine has been used in this country, and for the same purpose. It would have been more satisfactory if Mr. Crookes had stated, in regard to this board, who made it, or who made the spring balance; for may be, it was in fault, and if so, with a starting point at least 3 pounds wrong, how can we depend upon the expression of 6 pounds psychic force, as developed by the oscillation of the board? The experiments described are only two in number. An accordion, held upside down in the hands of the "medium," seemed to emit sounds, and when the "medium's" hand was removed, floated in the air. The board and spring balance, described as above, formed the second experiment. When Hermann astonishes the world by his floating wand, he does it as fairly as Mr. Home, but does not claim for it other than an example of his skill at prestidigitation. Scientific men tell us that no deceptions are more easy than those involving position of sound, or rather the determination of the source of sound. An accordion has always been a favorite instrument in the hands of "mediums," not so much on account of its portability as on account of similar sounds being readily produced by devices very readily concealed, if not by the mouth of the operator. A careful examination of Mr. Crookes' paper gives the impression that all the apparatus used was prepared without the knowledge of Mr. Home, and that any collusion was impossible; but still, there is wanting a degree of emphasis which should have specified these conditions.

"Before Mr. Home entered the room the apparatus had been arranged in position, and he had not even had the object of some of it explained before sitting down." Mr. Crookes should have stated which part of the apparatus he alluded to when he said "some of it," &c. Let it be discovered that the 6 pound mahogany board was furnished by Mr. Home, and the experiments will not be so

convincing, for nothing would be easier than the arrangement of machinery which should enable the operator to do what Home did, and would defy detection short of chopping up the board or destroying the spring balance. For my part, I feel sure that the same thing can be done by purely mechanical means with any board and any spring balance, provided those who see the experiment are not told before hand that the experiment is a mere feat of sleight-of-hand. Practitioners of "magic" will thank Mr. Crookes for putting their art among the sciences and for furnishing them with a new term. We shall now hear from the juggler's stage a scientific lecture, fully illustrated, to prove the possibilities of the new "psychic" force.

Mr. Crookes tells us, with great exactness, where the accordion used in "these experiments" was purchased, and, further, that it had not been seen or handled by Mr. Home previous "to these experiments." He further alludes to other experiments having been tried at his own house prior to those on the evening which he writes about—some with positive and some with negative results; he leaves us, however, in the dark as to whether "these experiments" alludes to all, at different times, or those of this particular evening. If the purchase of the accordion was so important a matter, surely the experiment with the board and balance, which he considers more conclusive, would warrant the same exactness as regards the origin of the board, provided it had not been purchased by Mr. Home as a piece of apparatus adapted to his requirements.*

Bibliographical Notices.

The Roadmaster's Assistant and Section Master's Guide, a manual of reference for all having to do with the permanent way of American Railroads. By William S. Huntington. Chicago: A. N. Kellog, 1871.

The active and extensive construction of new railroads, and the crowded trains upon those in actual use, make a well digested and sound practical work upon the subject of laying and repairing the

* It may be well to state that the author of this critique is quite as accomplished in the field of legerdemain as in that of mechanics. This fact, which is known however only to a privileged circle of friends, to whom the occasional exhibition of his proficiency in the art will be recalled in this connection with great interest, lends to his review a peculiar value.—Ed.

track, valuable not only to practical men, having charge of construction and repairs, but of those who bear the expense. This little octo decimo volume, of scarce one hundred pages, gives, as the writer claims, the results of twenty-five years experience in track laying and track repairs, in various circumstances of good and bad roads and management. The volume is, he says, a practical book for practical men, and it bears internal evidence that the writer is one of that class. The subjects treated comprise, apparently, the various larger and lesser details of materials and management necessary to make and maintain a good and safe track, with a copious table of contents and a copious index. We have no hesitation in commending this little work, not only to all practical track layers, but to all who are both directly and indirectly in authority over them. We rejoice, as well in our editorial capacity as in that of railroad passenger, that our author concludes by a chapter upon the subject of *accidents*, and the means of avoiding them, among which the proper construction and maintenance of track is of very great importance. May the warnings herein contained sink deep into the hearts of railway directors, and may the motto with which the author finishes his work become also theirs: "*Eternal vigilance is the price of safety.*" As to the Tyler Safety Switch, which our author recommends, we have naught to say against it, but we would encourage the managers of railroads not to omit examination of the Wharton Switch; in fact, to spare no pains to secure the best switch, by whomsoever made or sold.

Tables for Calculating Excavation and Embankment. By E. C. Rice, C. E. R. P. Studley & Co., St. Louis, 1870.

This is a well printed folio of some fifty pages. It begins with four pages of theoretical and practical introduction, which omits all notice of previous works upon the same subject. This part of the work contains nothing which, in our opinion, is deserving of notice on account of its novelty; but this may sometimes be said of books which have practical advantages over their predecessors. The following description may aid our readers in judging how far this is the case in the present instance. The first set of tables, fifteen in number, occupying 18 pages, apply to prismoids 100 feet long, of level-topped cross section. These tables are adapted to nine differ-